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VOSS, Ronald Eugene, 1939-
RESPONSE BY CORN TO NPK FERTILIZATION
OF MARSHALL AND MONONA SOILS AS
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METEOROLOGICAL FACTORS.

Iowa State University, Ph.D., 1969
Agronomy

University Microfilms, Inc., Ann Arbor, Michigan

RESPONSE BY CORN TO NPK FERTILIZATION OF MARSHALL AND MONONA SOILS AS INFLUENCED BY MANAGEMENT AND METEOROLOGICAL FACTORS

by

Ronald Eugene Voss

A Dissertation Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
DOCTOR OF PHILOSOPHY

Major Subject: Soil Fertility

Approved:

Signature was redacted for privacy.

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Iowa State University
Ames, Iowa

1969

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INTRODUCTION

In recent years farmers have harvested crops with yield levels far above those visualized as possible 25 years ago. These high yields are the result of farmers putting into practice technological advancements achieved through research by agronomists, botanists, entomologists, meteorologists, and others. As many limiting factors to yield are being reduced or even eliminated, not only are new factors encountered, but the importance of combinations of these factors has become obvious. Because these combinations are important, research specialists must heed factors which affect yield but which lie outside their area of specialty. For example, geneticists must be conscious of how a new variety will respond to fertilization; entomologists and pathologists must be aware of possible variability among varieties in genetic resistance to insects and diseases; and soil fertility researchers must be aware of the effect of weather on response to fertilizer. If the results of field experiments are to be meaningful, all of these and many other interactions must be heeded.

The method of field research in which the effect of one factor on yield is studied by "replicating" or averaging across many levels of other factors is an antiquated approach. If yields are to continue to rise, we must know the contributions of each of the major soil, plant and micro-meteorological parameters, and the interactions among these parameters. As Collis and Davey (1960), among others, emphasized, the importance of and inter-relationship among those parameters which control biological response cannot be explained until a more comprehensive style of measurement for determining these parameters is adopted.

The emphasis of research under field conditions, an environment which is largely uncontrolled, must be towards a quantitative characterization of the family of relationships which exist among the various controlled and uncontrolled factors in any given population. Thus, all factors which vary in an experiment and which may have a significant influence on the results obtained must be evaluated quantitatively if these relationships are to be characterized and the results applied to the population in general.

The objective of this investigation was to characterize the relationships among various controlled and uncontrolled soil, plant, climate and management factors as they influence the response by corn to applied N, P and K fertilization on Marshall and Monona soils of Western Iowa. In achieving this objective some general, as well as specific, guidelines were prepared and employed which can be used by research workers who are concerned with biological response by economic crops grown in uncontrolled systems. Factors which may influence this response are discussed and some methods of measurements are suggested. Multiple regression techniques were used to combine the data so that the relative importance of the effects of the different variables, alone and through interactions with other factors, could be determined.

A second objective was to study the relationships between the N, P and K concentrations in the corn leaves at silking and the grain yields at maturity and to study factors which influence these relationships.

A third objective was to investigate the possibility of a rootworm activity-soil fertility interaction. Some studies have indicated that the degree of rootworm larvae infestation and subsequent root damage may be related to the fertility level of the soil.

PART I. YIELD RESPONSE

LITERATURE REVIEW

Factors Which Influence Yield

Many comprehensive reviews of the factors which influence corn production are available. The entire book Advances in Corn Production: Principles and Practices, edited by Pierre, Aldrich and Martin, is devoted to this subject. More recent reviews have been made by Desselle (1967) and Christensen (1968). Generally, these factors are discussed in the specific areas of soil, plant, management and climate. A broader classification would be to divide the factors into classes of those which can be measured and those which, practically speaking, cannot be measured. Within each area of measured or nonmeasured factors, some are controlled and some are not controlled.

The specific factors are discussed individually, but it is the summation of the effects of all these factors, both through direct influence and through interaction with the other factors, which determines the quantity and quality of the crop.

Soil factors

That nitrogen plays a major role in determining corn yields is a fact undisputed today. The almost exclusive practice of a corn-meadow rotation of some type used by farmers until a few years ago was largely because of the nitrogen contribution made by the legume (Shrader et al., 1966). When fertilizer nitrogen became economical, the use of rotations decreased rapidly. Nitrogen was the first limiting factor encountered by Krantz (1949) when continuous corn was grown. Since then numerous responses to nitrogen by corn have been reported (Hanks and Tanner, 1952; Hutton et al., 1956; Jordan et al., 1958; Voss, 1962; Desselle, 1967; Christensen, 1968; and others). Most of these investigators have found that the degree of response was greatly influenced by climatic conditions and indigenous nitrogen. In general, response to applied nitrogen increased with more favorable climatic conditions and decreased with increasing amounts of soil nitrogen. Many articles in the literature cite interactions between nitrogen and other applied or indigenous soil nutrients (Dumenil and Nelson, 1948; Voss, 1962; Shah, 1965; and Desselle, 1967).

The positive interaction between plant population and response to nitrogen is well documented. Krantz (1949), Duncan (1954), Dungan et al. (1958), Jordan et al. (1958), Rossman and Cook (1966), Shah (1965), Desselle (1967), and Christensen (1968), among others, all reported this phenomenon. Desselle and Voss both reported that response to nitrogen varied with planting date and from hybrid to hybrid. Later .

planting generally decreased the responses, as did hybrids with lower yielding capacities.

While the response by corn to phosphorous has not been observed to be as consistent as that to nitrogen, the literature emphasizes that responses of great magnitude can be expected on soils that are low in initial supply (Krantz, 1949; Hutton, et al., 1956.

Christensen (1968) found that the response to soil P, which is usually most concentrated in the surface soil, increased as available soil moisture increased, but that under limited soil moisture applied P resulted in more efficient use of the limited moisture. However, Engelstad and Doll (1961) found that the differences in P applications required to give maximum net return were relatively small over a wide range of rainfall amounts observed for 12 years in Kentucky.

Generally, the response by corn on Iowa soils to potassium has not been large, and frequently yield depressions have been recorded, particularly where an unbalanced fertilizer combination has been applied. However, Barber and Mederski (1966) reported that only nitrogen surpasses potassium in pounds applied annually to corn in the Corn Belt. The response to applied K has been highly correlated with soil K levels (Krantz, 1949; Hanway et al., 1962). Grimes (1966) suggests that first year corn after meadow could be expected to respond more frequently than second year, or later, corn. The corn stover from a crop in which 100 bushels per acre of grain has been harvested will contain 100-150 pounds of K (Voss, 1966). If this stover is returned to the soil, the K in the stover diffuses rapidly and completely into the soil thus acting similarly to the addition of 100 to 150 pounds of commercial fertilizer potassium (Grimes, 1966). This addition would be lacking from first year corn or from fields in which the previous corn crop was removed as silage.

The relationship between yield and soil pH is not clearly defined, especially on Iowa soils, where extremely acid soils are not found. However, Voss (1962), Desselle (1967) and Christensen (1968) all found increasing yields with increasing soil pH. Desselle found a high correlation between soil pH and nitrification which, he concluded, resulted in increased yields because of the increased nitrogen. Lime rate experiments have not generally substantiated the theory that it is profitable to raise the soil pH to 6.5 or 7.0. The few increased yields from the addition of calcium carbonate have been inconsistent and apparently indirectly induced through increased soil nitrogen released through microbial action (Stryker, 1967; Claasen, 1969).

Physical properties of a soil have long been recognized as having a definite influence on crop growth. They are generally regarded as factors which have more indirect effect than direct effect, in contrast to soil N, P and K, for example. Soil texture, bulk and particle density, and soil depth are the primary factors which determine the available moisture capacity of a given soil (Shaw et al., 1959). Recently, more attention has been given to the possible effect of aggregation and aggregate size on nutrient availability. Tabatabai and Hanway (1968) found that K uptake by ryegrass in the greenhouse was not related to aggregate size. This study included 14 soils and aggregate sizes from 1 mm. to >9 mm. in diameter. They also found that different sized aggregates from any one soil sample did not differ in exchangeable K, "available" P, soil pH, or percentages of sand, silt or clay.

Plant or crop factors

It is generally accepted that different plant species have different soil, climate and management requirements for optimum growth. That different varieties within a given species also respond differently to fertilization has been substantiated by Duncan (1954), Dungan et al. (1958), Desselle (1967), and others. The Iowa Corn Yield Test Report, published annually by the Iowa Crop Improvement Association, verifies that different varieties vary in their yielding capacities (Hillson and Hutchcroft, 1967). That the yield ratings of the many varieties do not hold constant from year to year illustrates interaction between genetics and environment.

Management factors

Management is a broad, not easily defined, term encompassing topics ranging from selection of crop to harvesting techniques. Subjects which the literature indicates definitely affect corn yields include cropping system, past fertilization and liming, tillage procedures, planting time, plant population, weed and insect control, and variety selection.

Shrader et al. (1966) analyzed the yields of corn under six types of cropping systems, ranging from continuous corn to corn after three years of meadow. They revealed that without additional nitrogen, each system resulted in different yields. However, with varying rates of applied nitrogen, a common response curve could be fitted to all systems. The starting points (zero applied N) were different for the different systems, but the response to applied N then followed the common response with the increasing increments.

The influence of past fertilization and liming has been illustrated by Krantz (1949), Hutton et al. (1956), Voss (1966) and others. Krantz (1949) and Hutton et al. (1956) measured responses to P fertilization generally only where the previous crop had not been fertilized. These investigations, in addition to many others, including Voss (1962), Desselle (1967) and Christensen (1968) found the response to both P and K a function of soil test level, which in many cases reflects past fertilization.

Larson and Blake (1966) in their review of current literature on tillage and seedbed requirements stress the importance of these operations on the physical condition of the soil. The properties of tilth, moisture, aeration, temperature and strength can all be improved with the proper types, timing and quantity of tillage operations. The proper operations are a function of other management practices and of climatic conditions.

The importance of planting date and the possible advantages of early planting has received increasing attention in the past ten years. Rossman and Cook (1966) point out that this is due to improvements in seed quality and disease and weed prevention and control. They reported that the importance of planting date has been more important in the northern portions of the Corn Belt, where the growing season is cooler and shorter, and where rainfall distribution is likely to be limited during tasseling, silking, and early ear development. Voss (1962), Desselle (1967) and Christensen (1968) found earlier planted corn in Iowa resulted in higher yields. Duncan (1968) reported that research conducted in Iowa in 1965 and 1966 revealed late April planting gave the highest yields, but that the yield decline did not become serious until after May 10.

The most striking consensus of the literature concerning plant population is that it does not exert a large influence on yield independent from other factors, particularly fertility, soil moisture and several management factors. Richey, in 1933, concluded that optimum stand increased as one proceeded from south to north, low to high moisture supply, low to high soil productivity and genetically larger to smaller plants. These observations have been proved repeatedly since then and are generally accepted as fact today. That the interaction between population and other factors is not positive over an infinite range of population is also frequently reported in the literature (Termunde et al., 1963).

The direction of the effect of weeds on corn yields is well known, but the exact degree of this depression has been difficult to determine. Yield reductions of unweeded corn vary greatly depending upon the specific weed populations, fertility and on climatic conditions (Dunham, 1964; Buchholtz, 1963; and Staniforth, 1957).

Corn, like most crops, serves as a host for some specific insects. The two most damaging are the European corn borer and the corn rootworm. In addition, several insects attack the seed and/or seedlings (Petty and Apple, 1966).

As with insects, many types of disease can attack a corn plant if environmental conditions favor the pathogen. These include seed and seedling rots, stalk rot, smut, leaf blight, ear rot and virus diseases. But, as Ullstrup (1966) pointed out, corn is a comparatively healthy crop in the U.S. with very few instances of limited production over an appreciable area due to disease.

Climatic factors

Weather may be the most limiting single factor to corn yields in the Corn Belt, and other areas as well. As the average corn yield for Iowa has nearly linearly increased from 55 bushels per acre in 1943 to 93 bushels per acre in 1968, any negative deviation from this linear increased trend can be accounted for by the lack of favorable climatic conditions (Thompson, 1966).

Climate is a broad topic; and, the exact meteorological parameters which are responsible for influencing plant growth have not been fully established. However, many refinements from earlier studies have been accomplished. Until at least 1960, uncontrolled variables such as rainfall, temperature, relative humidity and soil moisture were measured and used directly in attempting to explain yield variability (Davis and Harrell, 1941; Bates, 1955; Mederski and Wilson, 1960; and Shah, 1965).

Despite this use of raw weather data and resultant high correlations between them and crop yields, prediction value of most of the derived formulas have been generally poor (Sanderson, 1954). Laing (1966) concluded that such variables are either not directly related to the production processes limiting crop yield or the relationships are not adequately described by simple regression. Additionally, correlations themselves do not provide evidence of causation. As a result, since the 1950's new concepts and indices of weather variables have been sought. Many different types of drought day indices have been developed (van Bavel, 1953; Parks and Knetsch, 1959; Ewalt et al., 1961: Schwanke, 1963; Dale and Shaw, 1965).

The drought day index reported by Dale and Shaw (1965), which they termed Stress Day Index, was a culmination of investigations by Denmead and Shaw (1962), Voss (1962), Shaw (1963) and Dale (1964) in which the criterion for stress was based on whether the plants' demand for water was being provided by the soil. Any day on which the available soil moisture was less than that required to prevent turgor loss was termed a Stress Day. If this ratio of available over needed soil moisture was greater than 1.0, the day was termed a Nonstress Day. In order to calculate these parameters the daily available soil moisture in the root zone and in the top foot of soil and the available soil moisture required to prevent turgor loss must be determined. Shaw's (1963) water balance method of estimating soil moisture and the relationship between evapotranspiration and percent of available field capacity in the root zone were used in estimating the necessary inputs. Dale (1964) assumed that the presence or absence of stress on any day from six weeks prior and three weeks subsequent to silking had an equally important effect on yield. He was able to explain over 80% of yield variation over a 30 year period using the number of stress days in combination with plant population. Desselle (1967) and Christensen (1968) used Dale's stress day criterion in helping to explain yield variation among fertilizer rate experiments across Iowa on loess soils. Desselle divided the growing season into four periods as originally defined by Voss (1962). The first period covered the five weeks after planting; the second period consisted of four weeks and corresponded to the growth stages between 24" high and start of tasseling; period three covered the three weeks before, during and after silking; and the fourth period, of six weeks, went to maturity. The third period has been considered by many as the time when stress, or absence of stress, is the most critical as to its influence on subsequent yields. Denmead and Shaw (1960) working under "controlled environment" conditions (i.e. corn was grown in five gallon crocks with water additions controlled) found that moisture stress prior to silking reduced grain yield 25%, moisture stress at silking reduced grain yield by 50% moisture stress after silking reduced grain yield by 21%. Furthermore, interactions between the three periods were not statistically significant. Under "uncontrolled" conditions, however, these interaction must be anticipated in much of the Corn Belt since July and August are months of lowest rainfall and greatest solar radiation: thus, if stress occurs prior to July, it will probably occur subsequently also (Runge and Odell, 1958). Desselle (1967) observed interactions among the first and second, second and third, and third and fourth periods of his study. Christensen (1968), in contrast to Desselle and Voss, reported that the breakdown of the growing season into periods did not improve the relationship between yield and stress over the utilization of total number of stress days (or nonstress days) in the period six weeks before and three weeks after silking. This concurred with Dale's earlier findings.

Laing (1966) advocated that the relationships among yield reduction, soil moisture stress and transpiration reductions are not accounted for in stress indices and that an index based on direct physiological reactions of the plant to its environment must be formulated and utilized. He developed an index, using soybean plants, based on the relative turgidity of the crop canopy at 2:00 PM of each day during the "critical" weeks of the growing season. The development of this index consisted of 1) determining the period of growth most susceptible to water stress; 2) estimation of daily soil moisture using Shaw's (1963) water balance method; 3) estimation of daily relative turgidity (RT) of the canopy using daily soil moisture and pan evaporation data, in combination with experimentally obtained concepts; and 4) transformation of RT into relative photosynthesis (p/p_o). The ratio, p/p_o, represents the proportion of photosynthesis with a given RT compared with the amount of photosynthesis with full turgor. Thus, depending on the RT value estimated for a given day, a value for p/p_o between 0.00 and 1.00 was assigned. These values for each day during the critical period were accumulated and the total, with a maximum value equal to the number of days of the critical period, was the index of water stress. A linear regression model (the quadratic term was nonsignificant) containing only the intercept and sum of p/p_o terms resulted in an R^2 of 0.74 when the index was evaluated using 21 years of Hawkeye, medium maturity, soybeans. An examination of the data reveals, however, a concentration of points at high yields (and $\Sigma p/p_o$) with few points at low levels.

A modification in Laing's relative photosynthesis index was made by Shaw in 1968. Laing developed the relationship between RT and soil matric potential at potentials ranging from 0 to 5 atmospheres (approximately 100% to 30% available soil moisture) and extrapolated the relationship to 15 atmospheres (0% ASM). Shaw found his extrapolation to be incorrect in that RT does not decline as rapidly as Laing had indicated when soil potential increases. Thus, the resultant relative photosynthesis values obtained from Shaw's modification are generally higher than those predicted from Laing's original relationships.

Stevenson (1969) has attempted to develop leaf resistance as an index of moisture stress. Leaf resistance is simply the resistance to movement of water vapor out of the leaf stomatal openings and is the summation of stomatal pore resistance, internal air spaces and cell wall resistance. The latter are nearly constant indicating that pore resistance is the major factor. In comparison with Laing's index, Stevenson found that wilting began at about 89-90% RT rather than the 86% which Laing determined. In general, however, the two indices appear highly correlated.

Review of Methods Used in Evaluating Fertilizer Response in an Uncontrolled Environment

Concepts in field experimentation have changed greatly in the past 20 years. Emphasis has switched from the study of a single controlled factor to the simultaneous study of many factors, both controlled and uncontrolled. Yet, if crop production is to continue to increase as rapidly as it has, more refinements in techniques, as well as concepts, are necessary. A review of the trend in advancements in field experimentation helps to serve as an indication of further refinements which are necessary and which can be accomplished today.

<u>Prior to 1950</u>

Until the 1950's the literature contains, almost exclusively, the results of investigations which were conducted utilizing simple statistical designs and analyses. The effect of a simple experimental variable, <u>e.g</u>. one fertilizer nutrient, was studied. In this type of experimentation the first step, and perhaps the most critical one, was the selection of a uniform appearing site. All controlled variables, except the applied variable being studied, were held constant, theoretically, within the site. Frequently, the level at which they were held was not specified in the literature. The controlled variable under study was applied at various levels according to one of the common statistical designs. Several replications of each level were applied in an attempt to adjust for variability of all other factors and to provide an estimate of experimental error for statistical purposes. No quantitative evaluation of uncontrolled variables were accomplished. Thus, the results obtained from these experiments were the effect of one controlled variable at constant levels of other controlled variables and averaged across the levels of uncontrolled variables.

Factorial experiments

Dumenil and Nelson (1948) emphasized the importance of more detailed investigations. Utilizing a factorial arrangement of N, P, and K fertilizers, they observed significant interactions between the different fertilizer nutrients in 62 of 164 experiments. They found further that these interactions varied from soil type to soil type and with different climatic conditions. They concluded that without the factorial arrangement, erroneous interpretations would have resulted wherever interactions between the fertilizer elements occurred.

The procedures in conducting factorial experiments were not vastly different from previous experiments. The selection of uniform sites was paramount because uncontrolled variables were still not measured. Two or more controlled variables were applied at several levels of each. Other controlled factors were kept at a constant level. Replication was still necessary to give an average across uncontrolled variables and for an estimate of experimental error. The results from these factorial experiments did enable a measure of interaction among applied variables and between applied and other controlled variables among sites. But, no measure was obtained of interactions between applied and other controlled variables within sites or between applied and uncontrolled or unmeasured variables. In addition, the number of treatment combinations frequently became prohibitive when it was necessary to study three factors at five rates, with even two replications, for example.

Realization of variability

The fact that many variables, both controllable and uncontrollable, were not actually being held at a constant level was emphasized with the realization that soil is not homogeneous, even within the small area of a carefully selected site. Inherent soil chemical, physical and morphological properties have been found to vary within areas that appeared uniform to the eye. Since Cline's classic paper in 1944, many other investigators have illustrated variability within small areas (Rigney and Reed, 1945; Barker and Steyn, 1956; Mader, 1963; Desselle, 1967; and Turrent, 1968). Statistical analyses by these investigators revealed that this variability tends to be random rather than systematic and that the degree of variation depends on soil type and the specific properties being measured.

Various conclusions have been reached concerning the degree of variability depending upon the assumptions and statistical approach of the respective investigators. Desselle (1967) assumed that within an experimental area each plot was an individual sample and each replicate a finite population. He tested the null hypothesis that no difference existed between two population samples by pairing plots in one replicate with plots in a second replicate at the same site. Student's t-test was used for determining the statistical significance of the differences between two paired samples for each of four chemical soil tests- N, P, K and pH. He found that at least 2 of the 4 properties were statistically different at 21 of 22 sites.

Using somewhat a different approach, Turrent (1968) reached somewhat different conclusions. He sampled four fields on the same farm. From each field, ten plots of 1/100 acre were sampled and the samples divided for two separate laboratory analyses. From the results he was able to ascertain 1) a systematic difference - the real plot to plot variation, 2) sampling error, 3) laboratory processing error, and 4) experimental error, which was the sum of sampling plus laboratory errors. Using the criterion that the Mean Square for any of the nutrients at a site (systematic difference) must be five times larger that the Error Mean Square, Turrent found in 38 experiments, some the same as used by Desselle, only 2, 15, 25, and 6 sites were significantly different with respect to soil test values for N, P, K, and pH, respectively. He assumed that the size of experimental error was homogeneous from site to site with the value of 55, 14, 188 and .01 for N, P, K and pH, respectively. The literature contains little to validate this assumption, and it would appear that extrapolation of experimental error values obtained from one soil type to several other soil types may not be justified. Furthermore, his criterion for an F-value of 5.0 or greater appears to be somewhat arbitrary and may result in Type II errors, accepting the hypothesis that no difference exists when it actually does. However, his approach did permit observed variation in soil test values to be partitioned into laboratory error, sampling error and true variability, in contrast to most earlier studies.

The fact that some sites which appear uniform to the eye are actually heterogeneous reveals the need to sample and analyze areas smaller than a site, or even a replicate. It follows that either individual plots should be sampled or a sufficient number of systematically selected plots be sampled to permit mapping of trends across a site. The latter procedure would not be satisfactory for those sites which vary in a random rather than a systematic manner.

Measurement of soil properties enables a more complete characterization of the response to applied variables because it facilitates a measure of the interaction between applied, controlled variables and other measurable variables, whether controlled or uncontrolled.

<u>Refinement of measurements on both controlled and uncontrolled variables</u>

With the realization that theoretically controlled variables were not actually being held constant and that interactions among controlled and uncontrolled variables were frequently of great importance, advancements have been made toward the utilization and standardization of measurements on both controlled and uncontrolled variables. Measurement of all factors which affect the results of an experiment enables a maximum degree of explanation of the variation in the results through main effects and interactions. Theoretically, if all factors, controlled and uncontrolled, affecting the results of an experiment are measured, the only unexplained variation would be due to errors in measurement. But unless all factors are either held absolutely constant or measured, the importance of each factor itself or of any interactions cannot be determined.

The practical application of measuring all pertinent controlled and uncontrolled variables, thus the independent effects as well as the interaction effects, is the characterization of response surfaces which give the underlying relationships among factors within a given range. These response surfaces permit interpolation to areas not specifically studied but which fall within the range of values studied.

Yield response surfaces also permit the calculation of economically optimum fertilization rates.

Baird and Fitts (1956) emphasized that the development of such surfaces required large numbers of treatment combinations, such as with factorial designs. However, a factorial with 3 factors each at 5 rates results in 125 treatment combinations per replication. Consequently, adaptations of a central composite design authored by Box (1954) were suggested for use in field experimentation. Box's original design for a 5^3 factorial consisted of 15 semi-orthogonal treatment combinations: the three linear coefficients and the interaction coefficients were independent. Baird and Fitts (1956) employed a slight modification, using 18 points (treatment combinations). Voss (1962) found by adding 4 additional points to this latter design statistical independence between linear terms and interaction terms containing like variables was achieved. Tramel (1956) suggested the use of a "triple cube" design of 31 treatment combinations covering the same factor space.

Precision is a common method of comparing statistical designs. Anderson and Bancroft (1952) define precision as simply the inverse of variance, i.e. high precision is low variance. By examining the inverse matrix of respective designs, their relative precision can be ascertained. Box (1954) suggests comparing designs with unequal number of points by multiplying the inverse matrix of the respective designs by N, the number of treatment combinations, so that $\frac{1}{N}\Sigma(X_{it} - \bar{X}_1)^2$ is the same for both designs. Tramel (1956) compared the "triple cube" design with Box's original design by examining their respective precisions in estimating the intercept, linear, quadratic and interaction terms. He determined that the precision of the triple cube, relative to Box's design, was 350%, 100%, 136%, and 250% for estimating the intercept (b_0), linear, quadratic and interaction terms, respectively.

The greatest limitation of the use of central composite type designs is that they were originally intended for use in chemical laboratories, where the environmental conditions were perfectly controlled - quite different from the conditions of most agronomic studies. Thus, as Baird and Fitts (1956) emphasized, before these designs can be properly used, it is necessary to evaluate as completely as possible the effect of the uncontrolled factors.

The mathematical description most frequently used to describe response surfaces obtained from the central composite and other designs has been a polynomial equation of second order. The model contains linear, quadratic and second order interaction terms. Other expressions have been used and compared with the quadratic equation. Pesek _et al._, (1967) found in analyzing the results from several long term rotation experiments at three locations with a 3x3 factorial of applied P and K that a conventional quadratic equation best described the yield function for all years and crops. Anderson (1956) obtained similar results. Others who have utilized the quadratic equation successfully include Hutton et al. (1956) in a 5x5x5x2 factorial on corn; Jensen and Pesek (1959) in defining crop yields over a range of initial soil fertility levels; Voss and Pesek (1962) in describing dry matter yield of oats grown in the greenhouse as a function of N and P fertilizers and initial fertility level; and Voss (1962), Desselle (1967) and Christensen (1968) in describing corn yields as a function of many controlled and uncontrolled variables.

Tejeda (1966) compared the second degree polynomial with a rational fraction model, which describes an asymptotic response by Y to independent variables, X. He criticized the polynomial's characteristic of symmetry on either side of the maximum, emphasizing that such yield curves are difficult to find. His comparison, utilizing response of oats in the greenhouse to fertilizer, revealed, in general, only slightly higher multiple correlations with the rational fraction model.

The major advantages of the second order polynomial include ease of fitting and testing, good estimation of biological response over the range the values observed, and its usefulness in determining economical optimum combination of factors. These advantages are indicated by Cochran and

and Cox (1968), Baird and Mason (1959), Heady and Pesek (1956), and others.

Anderson (1956) presented some guidelines on whether or not to use yield data from plots where no variables have been applied. He observed that if the yield response curve is sigmoidal, indicating very low soil nutrient level, the omission of check plot data will result in better estimation by any of the commonly employed mathematical expressions. This is not the case if all data lie on the diminishing returns portion of the response curve.

Cady and Fuller (1968) proposed a method for calculating orthogonal polynomial coefficients when the levels of the independent variables are not equally spaced and/or replicated. Their method enables the determination of the coefficients by using a standard regression computer program, or even by means of a hand calculator. It is based on the orthogonality between the computed residuals and the independent variables in the regression analysis.

Fly and Romine (1964) stressed the need for guidelines in interpolating and extrapolating research results from one soil to another and from various soil-climate combinations. Heady and Pesek (1956) indicated that these guidelines can be predicted if the basic or underlying family of relationships are properly described. The current literature clearly indicates that this "underlying family of relationships" can only be described by quantitative measurement of the effect of all controlled and uncontrolled factors.

<u>Consideration of each individual plot as an independent sample of a given population</u>

If the general objective of field experimentation is to describe the "underlying family of relationships" among factors which affect crop growth, it appears that quantitative measurement of all these factors should be accomplished on an individual plot basis. This is in contrast to the past concept of a site or replicate being the smallest independent number of a given population. The yield measurement on an individual plot is the manifestation of all controlled and uncontrolled variables acting within that plot. Thus, for each yield datum, a corresponding datum for each variable should be recorded. The predefined population is then characterized from the combination of all population samples - individual plots. This population may be defined as a site, soil type, soil association area, county, state, etc. Combination of samples is accomplished through multiple regression techniques, where each plot is not considered a subsample of a member (<u>e.g</u>. site) population, but rather each plot is an independent sample of the entire population.

It is true that differences within each of many factors often cannot be measured among plots within a site.

Generally, site selection precludes more than one soil type within a site. But, if more than one does occur, they should be recorded as such. Similarly, meteorological conditions are usually considered to be similar within the smaller area of an experimental site. However, many types of sites do not even assure the validity of this assumption. Till soils, with varying amounts of coarse particles in the profile, can easily contain varying amounts of soil moisture within a small area. The lack of established drainage patterns of these same soils can also lead to different moisture regimes within a small area. The steeply rolling soils of Iowa which have been altered on the surface through the addition of terraces may have a gradient of moisture between two terraces.

The statistical tool of blocking is not a completely satisfactory method of accounting for these differences. A block difference tells only that there is a difference, not the nature of the difference nor the quantitative relationship with the dependent variable. Consequently, one or more members of the "underlying family of relationships" is not measured. The most satisfactory method of explaining this difference is to actually measure it as quantitatively and completely as economics and instrumentation will permit and assign a value to each plot. For example, soil moisture would be very expensive to measure in each plot throughout the growing season in an experiment which contained several hundred plots. However, the systematic placement of a few aluminum access tubes at a site and the periodic measurement of profile soil moisture with the aid of a neutron probe would permit evaluation of soil moisture at each plot through interpolation, which would be a vast improvement over the assumption that soil moisture is uniform within a site. This is of particular importance when the soil moisture content is near the lower limit of availability. When this situation is prevalent, plants on some plots may be receiving sufficient water while those on nearby plots are not.

Steps in Establishing Experimental Procedures

The review of methods used in evaluating crop response to fertilizer applications stresses the importance of determining which factors influence corn yields and of measuring their effects quantitatively. It further stresses the importance of standardizing the manner in which factors are defined and measured. In view of these facts the development of a stepwise procedure for selecting experimental methods and procedure appears appropriate. This procedure should apply to all field experimentation where the objectives pertain to determining the effects of some independent variables on one or more dependent variables.

The first step, of course, must be a statement of the specific objectives of the experiment.

Secondly, the factors which are likely to have an effect on the dependent variables and factors which are likely to influence response to the applied variables must be identified. That is, it is necessary to define all factors which significantly affect yield.

Third, it would appear logical to separate those factors whose effect cannot be measured or can be measured only with excessive difficulty or cost. These factors should be either avoided or eliminated as variables (i.e. held at a constant level).

Fourth, those factors which can be measured and controlled should be noted, keeping in mind the objective of the experiment. Factors which typically might apply here are soil type, cropping system, variety, plant population and geometry, tillage methods, planting time, weed growth, fertility, and others, depending upon the type of experimentation.

Fifth, considering time, money and labor available, in addition to the experimental objectives stated in step one, the following must be determined: 1) which controllable factors must be held at a constant level, 2) which uncontrollable factors can be measured and which cannot, and 3) the most appropriate number and location of plots and number of plots at each site. Plots within a site contain different levels of controlled factors, while different sites are essential to assure a coverage of a range in uncontrolled variables.

The last major step in planning a field experiment is the selection of the proper experimental design, which will be largely governed by step one and five, above. That is, applied variables (treatments) must be selected and allocated to plots within each site.

In general, the above stepwise guidelines were closely followed in planning this experiment in which the response by corn to fertilizer N, P, and K was studied. The objective was stated in the INTRODUCTION. The defining of factors that are likely to affect the response by corn can be accomplished through a review of the current literature. Next these factors were studied more closely to determine which ones to measure and what types of measurements can be and/or should be made.

EXPERIMENTAL METHODS AND PROCEDURES

Need for Standardization of Techniques

If the characterization of any family of relationships is to be of use by other investigators in adapting the results to their particular objectives, some standardization of methods and measurements is essential. A uniform method of field experimentation utilizing standard techniques would allow a smoother transition among individuals within a system (department, experiment station, university, a given industry, etc.), among systems, and among geographical areas, with respect to interpretation of results and adaptation of these results to different phases of research.

The complete characterization of a population with an uncontrolled environment necessitates measurement of many types of variables, most of which may lie outside one's immediate discipline. Thus, cooperation among the various disciplines (agronomy, economics, entomology, botany, statistics, etc.) is essential if variables are to be evaluated with minimum error and if standard techniques are to be generally used.

Variables for which standard methods and measurements are needed include soil sampling and analyses, plant sampling and analyses, evaluation of weed and insect damage, and measurement of meteorological factors, in addition to many routine field techniques. The techniques used in this experiment are believed to provide quantitative evaluations with errors as low as today's technology and economic considerations will permit. Many measurements are in need of vast improvements, others minor improvements, and others appear to be suitable as standard techniques now.

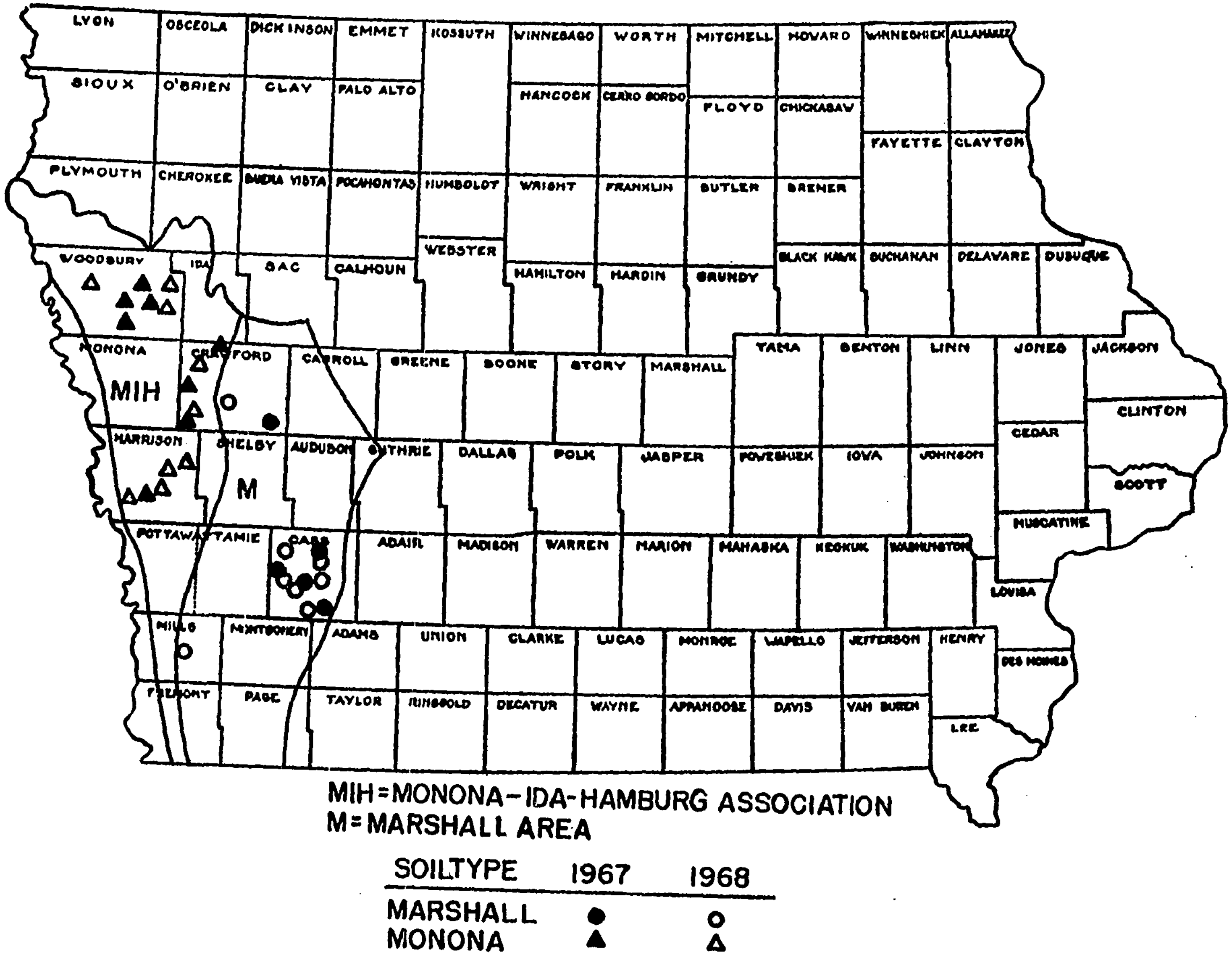
Factors Which Were Measured

Controlled factors

Control of independent variables can be achieved through addition, subtraction and/or selection. The use of selection provides a continuous scale from controlled to uncontrolled variables in a broad sense. However, within the confinements of one's specific objections, the range available for selection for some factors is limited. Thus, control is achieved primarily through addition and subtraction for some factors and selection for others.

Soil factors The soil factors which were controlled in this experiment were soil type, site selection and applied fertility. Sites for the field experiments were controlled by selection and were restricted to Marshall and Monona silt loam soils in western Iowa. The location of the experimental sites selected for this two year study are shown in Figure 1.

Figure 1. Location of experimental sites


LYON
OSCEOLA
DICKINSON
EMMET
KOSSUTH
WINNEBAGO
WORTH
MITCHELL
HOWARD
WINNESHIEK
ALLAMAKEE
SIOUX
O'BRIEN
CLAY
PALO ALTO
HANCOCK
CERRO GORDO
FLOYD
CHICKASAW
FAYETTE
CLAYTON
PLYMOUTH
CHEROKEE
BUENA VISTA
POCAHONTAS
HUMBOLDT
WRIGHT
FRANKLIN
BUTLER
BREMER
WOODBURY
IDA
SAC
CALHOUN
WEBSTER
HAMILTON
HARDIN
GRUNDY
BLACK HAWK
BUCHANAN
DELAWARE
DUBUQUE
MONONA
CRAWFORD
CARROLL
GREENE
BOONE
STORY
MARSHALL
TAMA
BENTON
LINN
JONES
JACKSON
MIH
CLINTON
CEDAR
HARRISON
SHELBY
AUDUBON
GUTHRIE
DALLAS
POLK
JASPER
POWESHIEK
IOWA
JOHNSON
M
SCOTT
MUSCATINE
POTTAWATTAMIE
CASS
ADAIR
MADISON
WARREN
MARION
MAHASKA
KEOKUK
WASHINGTON
LOUISA
MILLS
MONTGOMERY
ADAMS
UNION
CLARKE
LUCAS
MONROE
WAPELLO
JEFFERSON
HENRY
DES MOINES
FREMONT
PAGE
TAYLOR
RINGGOLD
DECATUR
WAYNE
APPANOOSE
DAVIS
VAN BUREN
LEE
MIH=MONONA-IDA-HAMBURG ASSOCIATION
M=MARSHALL AREA
SOILTYPE 1967 1968
MARSHALL ● ○
MONONA ▲ △

Each experimental site was adjacent to a site used by Dr. Lloyd Dumenil in the cooperative Corn Yield Research Study of the Iowa Agricultural Experiment Station, Extension Service and Soil Conservation Service. Three exceptions were sites located in fields adjacent to the Corn Yield Study plots. The soil profile at each site has been described and characterized by a soil scientist of the Soil Conservation Service and each site has been characterized with respect to past management and inherent fertility. Selection of sites was made to obtain the desired range of measured factors and to avoid sites with low levels of management, extreme heterogeneity or recent manuring or fertilization. Sites were selected from those where no manure or fertilizer had been applied for at least one year and no limestone had been applied for at least two years.

Each site was considered as a replicate with 25 identical fertilizer treatments which consisted of different rates of application of N, P, and K. Randomization of treatments was different at each site. All fertilizer materials were weighed and broadcast on the individual plots in the spring directly before plowing. No other fertilizer was applied to the experimental plots. Fertilizers to supply the N, P and K were applied as the solid form of ammonium nitrate (33.5-0-0), concentrated superphosphate (0-46-0) and muriate of potash (0-0-60), respectively. The nutrients were applied at five levels of each, as follows: N - 0 to 200 lbs. N/acre at 50 lb. increments; P - 0 to 60 lbs. P/acre at 15 lb. increments; and K - 0 to 120 lbs. K/acre at 30 lb. increments.

Plant factors Plant factors were highly controlled in this experiment as only corn was studied, and a single variety was grown at all sites. Dekalb XL361, which is a threeway cross of medium maturity was acceptable to all cooperators, has been proven in Iowa Corn Yield Tests to be consistently high yielding, and can be grown in all areas of Iowa.

Management factors Most management factors are controlled through selection. These include past cropping sequence, tillage procedures, planting method, past fertilization and liming, variety selection, plant geometry, and in a general manner, plant population. Weed and insect control can be achieved through either the addition of preventive methods or elimination methods if weeds or insects are present after the preventive stage. Cooperators were encouraged to achieve maximum weed and insect control. Sites with second or more year corn received applications of rootworm insecticide. Sites where weed control was not achieved, either through use of chemicals or cultivation, were hand weeded as much as possible. However, weed and insect control was often incomplete. Thus, the infestations were evaluated and considered as uncontrolled variables.

All plots were plowed in the spring immediately after fertilizer applications. All corn was drill planted by the cooperator in rows spaced 38" or 40" apart. Conventional tillage operations were conducted at all locations. No minimum tillage sites were selected.

Meterological factors Under the non-irrigated conditions of this experiment and nearly all of Iowa, little direct control over climate is available. Soil moisture conservation practices such as terracing, grassed waterways, fallowing, etc. can be practiced, but these controls were not considered in this experiment. Thus, climate was a completely uncontrolled variable.

Uncontrolled factors

Most of the factors measured in this experiment were not controlled. However, it is no less important to evaluate these factors quantitatively that it is the controlled factors. Because of the lack of control, thus absence of techniques to make them constant at all plots, a need for quantitative evaluation may be even more critical than for the controlled variables.

Soil factors Soil physical properties such as slope, aspect and degree of erosion were allowed to vary from site to site. The interpretations of the Soil Conservation Service for these soil properties at each Corn Yield Study site were used to describe each experimental site. Where the site deviated from the point of description, a clinometer was used to determine the slope. A value for "corn yielding potential" as described by Fenton (1968) was calculated to provide a quantitative index to evaluate each site, combining the effects of soil type, slope and erosion. These three factors and corresponding yield potential for each site are listed in Table 1.

The water holding capacity of the soil at each site was determined on composite soil samples of eight profiles sampled to a depth of five feet at six inch increments. The soil samples were collected in June of each year. Field capacity was estimated by determining the moisture content of the soil sample at 1/3 atmosphere suction and the lower level of available moisture was estimated by determining the moisture content at 15 atmosphere suction.

Soil samples for chemical analysis were obtained in the spring immediately prior to fertilizer application and subsequent plowing. Samples of the surface soil (0 to 6", approximate plow depth) of each plot consisted of a composite of 12 to 15 cores per plot. Profile samples representative of each site consisted of a composite of soil samples collected from eight systematically selected plots at 6 to 12, 12 to 24, 24 to 26, 36 to 48 and 48 to 60 inch depths.

Table 1. Corn yielding potentials as related to soil type, scope and erosion

Site number	Mapping symbol[a]	Yield potential bu/A
02	9-C-1	102
03	9-A-0	109
04	9-B-2	104
05	9-C-2	99
06	10-B-2	95
08	10-B-3	89
09	10-B-2	95
11	9-B-2	104
12	10-B-2	95
14	10-B-2	95
16	10-B-3	89
17	10-C-2	90
18	9-B-1	107
20	9-B-1	107
21	9-A-0	109
22	9-C-1	102
23	9-D-2	90
24	9-B-1	107
26	10-C-2	90
27	10-B-1	98
29	9-B-1	107
31	10-A-0	100
32	10-8-1	98
33	10-B-1	98
36	10-C-1	93
37	10-C-1	93
38	10-C-1	93
39	9-8-1	107
40	10-B-1	98

[a]Soil type: 9 = Marshall, 10 = Monona
Slope: A = 0-2%, B = 2-5%, C = 5-9%, D = 9-14%
Erosion: 0 = Top soil intact, 1 = 0-25% eroded, 2 = 25-50% eroded 3 = 75% eroded.

Soil sampling techniques similar to those used by Turrent (1968) were used to obtain samples to determine the sources of variability in soil test values within a site. Separate soil samples from the surface soil of 5 of the 25 plots at each site were obtained by two persons. Each sample was then split into two before laboratory analyses, and duplicate analyses were made in the laboratory.

Chemical analyses of each undried sample were made for "available" P, exchangeable K, soil pH, buffer pH, initial NH_4^+ and NO_3^-, ammonifiable N, and nitrifiable N, in the Iowa State University Soil Testing Laboratory by methods described by Eik in 1968. Samples were kept in the field moist condition in a cool room prior to analyses. Subsamples for each analysis were taken from a slurry containing 2 parts water and 1 part soil. The extracting solution for phosphorous was 0.025N HCL and 0.03$\underline{N}$ NH_4F and for potassium was 1$\underline{N}$ NH_4OAc. Soil pH was determined on the 2:1 H_2O: soil slurry, and buffer pH was determined as described by Schoemaker, McLean and Pratt (1961). Ammonifiable and nitrifiable nitrogen were determined by micro-Kjehldahl procedure after one and two week anaerobic and aerobic incubations, respectively.

The soil test results for the surface samples from each plot are listed in Appendix Table 45 and for the profile samples from each site in Appendix Table 39.

Management factors   Since one of the objectives of the experiment was to study the relationship between fertilizer response and cropping system, a range in cropping sequence was sought and selected. The cropping sequence varied from first year corn after two years meadow to fifth year corn. This factor was quantified using a modification of the coding system devised by Engelstad (1960), who did not have soybeans in his sequence combinations. The cropping sequences, the position in the sequence of the corn crop studied, and the coded value for each is shown in Table 2.

The planting rate was determined primarily by the cooperator. Although a final population of 16,000 plants per acre was suggested, a range from 13,000 to 21,000 plants per acre was observed. Stand counts for each plot were made during June each year. Within some experimental sites excess plants were rogued from the more heavily populated plots to produce more uniform stands within the site. No plants were removed from plots at sites where the stand levels were already below the desired density of 16,000 plants per acre.

Measurements of weed and insect damage, which were not completely controlled as per the objective, were made at harvest time. Before picking, root and stalk lodging counts

Table 2. Code numbers assigned to various cropping systems

System[a]	Code number
M-M-C	0.8
M-C	1.0
O_M-C	1.5
C-S_b-C	1.7
M-C-C	2.0
O_M-C-C	2.5
C-Sb-C-C	2.7
M-C-C-C	3.0
Sb-C-C-C	3.7
M-C-C-C-C	4.0
Sb-C-C-C-C	4.7
M-C-C-C-C-C	5.0

[a]C=corn, M=legume meadow, Sb=soybeans, O=oats experimental year's crop underlined.

were made on each plot. Results were expressed as a percent of total plants. Stalk lodging, primarily the result of corn borer activity, was divided into two categories, broken at or above the ear node and broken below the ear node. Root lodging was classed as not lodged, moderately lodged, or severely lodged. A severely lodged plant was one which formed an angle with the ground surface of less than 30 degrees. Moderately lodged plants formed an angle of 30-60 degrees, and those which were at an angle of 60-90 degrees were considered to be not lodged.

Weed infestation was generally uniform within a site. At all sites the broadleaf weeds were successfully destroyed early in the growing season. However, at some sites appreciable grass infestation did occur. If more than 200 lbs. per acre was estimated to be present, the weeds were cut from five random locations within the site. Each of the five samples were three feet wide across four rows. The weeds were dried and the average weight on a per acre basis was recorded. The amount of weed infestation at each site was assigned a coded value, as listed in Table 3. At two sites grass infestation was not uniform within the site. In one instance a random infestation of quackgrass occurred; in the second instance four rows failed to receive atrazine herbicide that the remainder of the site had received. In these two cases, weed infestation could not be considered a site variable and coded values were assigned on a plot basis.

At sites where second or more year corn was being grown, root samples from five plants were obtained from each plot. The rootworm specialists within the entomology department at Iowa State University rated each root as to its relative size and relative rootworm damage. These coded ratings are listed in Table 4 (Peters and Eiben, 1964).

Meteorological factors Direct measurements of daily precipitation for each site were made by the cooperator throughout the growing season by means of small rain gauges located

Table 3. Coded values assigned to the extent of infestation of grassy weeds

Code	Weed infestation, lbs/acre
0	0-300
1	300-600
2	600-900
3	900-1200
4	>1200

near the experimental site. The available soil moisture (ASM) in the soil profile to a depth of five feet by six inch increments was determined on soil samples collected from each site in June. Data for daily pan evaporation from the nearest weather station that made this measurement were used. The silking date, which was required for calculation of some of the meteorological indices, was determined for each plot by counting the number of silks which had emerged on two or more dates and calculating the date when 75% of the plants in the plot were silked. The average date for all plots at each site was used. Two indices and a modification of each were calculated to help explain site to site variation in yield and to explain the variation in many interactions from site to site.

Table 4. Iowa corn root rating system

Size (recovery)		Damage	
Rating	Description	Rating	Description
0	No apparent recovery	1	No damage or few minor feeding scars
1	Few (4-6) roots on top node showing regrowth	2	Feeding scars, but only 1 or 2 roots eaten off to within 1 1/2 inches of plant
2	Top ring of roots all showing at least some growth	3	Many roots eaten off to within 1 1/2 inches of plant but never the equivalent of an entire node of roots gone
3	Considerable secondary roots and complete node of regrowth	4	One ring or node of roots completely destroyed
4	Regrowth on more than one node and good secondary development	5	Two rings or nodes of root completely destroyed
5	A "value judgment" of excellence	6	Three or more rings or nodes destroyed

The first index was Dale's (1964) stress day-nonstress day index, which was discussed in the Review of Literature section. This is a qualitative index which classifies each day as either stress or nonstress, without apparent regard for degree. The stress ratio for each day was calculated with an IBM-360 digital computer as programmed by Dale and Hartley (1963). Inputs required are percent ASM at an arbitrary starting date in the five foot profile by six inch increments, daily precipitation, daily pan evaporation, and silking date.

The modification of the stress-nonstress day index was a quantification of the index, which was achieved by regarding the actual value of the ratio. The rationale for this procedure is that a plant on a day with a ratio of 0.20 is probably under more stress than a plant on a day with a ratio of 0.95, both of which would be classed as stress days under Dale's qualitative interpretation. All ratios of 1.00 and greater were given a value of 1.00 to indicate no stress. The sum of the ratios for the growing season or for any given period within the season would give a "non-stress index" for that period. For example, if the period 6 weeks before and 3 weeks after silking were considered, a maximum "nonstress index" value of 63.0 would be possible if every day of the 63 day period had a stress ratio of 1.00 or greater.

The second type of moisture stress index which was investigated was the relative photosynthesis index of Laing (1966). Relative photosynthesis (p/p_o) was calculated from the output of Dale and Hartley's (1963) program. Soil matric potential, a function of ASM, is converted to a relative turgidity (RT) percentage, which in turn is coded into p/p_o. The ratio p/p_o is defined as the amount of photosynthesis achieved in relation to the potential photosynthesis which would be expected at 100% RT. A value of 1.0 for p/p_o is the maximum achievable value for a given day. As with the nonstress index, these daily values are summed over the growing season or period of the season.

Shaw's (1968) modification, as discussed in the Review of Literature section, was also utilized to assess moisture stress.

Table 5 lists the range in values of the uncontrolled factors which were measured as variables in this study. From previous knowledge it appears that the population of Marshall and Monona soils was adequately sampled with respect to expected range of values within the population. Also, listed in Table 5 are the ranges of the applied fertilizer variables and the range in grain yields which were measured.

Table 5. Range in values of the variables studied

Variable	Code[a]	Range 1967	Range 1968
Crop sequence	R	0.8-5.0	1.0-4.7
Planting date	T	May 9-25	May 1 - 11
Weeds	W	0-3.0	0-1.0
Plant population	S	12,500-19,800	13,500-21,600
Soil yield potential	C	89-109 bu/A	90-109 bu/A
Soil N	n	56-92 pp2m	52-75 pp2m
Soil P	p	11-42 pp2m	8-83 pp2m
Soil pH	a	6.0-7.0	6.0-7.0
Subsoil N	n_s	18-56 pp2m	22-36 pp2m
Subsoil P	p_s	6-18 pp2m	6-26 pp2m
Subsoil K	k_s	70-186 pp2m	78-212 pp2m
Subsoil pH	a_s	6.0-7.7	6.0-7.3
Stress days[b]	D_1	12-33	21-57
Nonstress index[b]	D_2	51-61	32-57
Relative Ps[b]	D_4	22-46	0.5-39
Relative Ps (Shaw)[b]	D_3	39-57	7-47
Yield	Y	53-153	27-135
Ave. site yield	Y_A	94-135	50-116
Applied N	N	0-200 lbs./A	0-200 lbs./A
Applied P	P	0-60 lbs./A	0-60 lbs./A
Applied K	K	0-120 lbs./A	0-120 lbs./A

[a]These coding symbols will be used throughout the text.

[b]Values based on period 6 weeks before and 3 weeks after silking.

Factors Which Were Not Measured

Efforts were made to avoid or eliminate as variables all factors which would be expected to significantly influence corn yields or yield response, but which were not to be measured. This was done by restricting the area of the study to corn on Marshall and Monona soils in western Iowa, by selecting sites to avoid undesired variables within the area, and by holding some variables constant over all sites; for example, all sites were spring plowed.

Techniques in Measuring Dependent Variables

The dependent variables measured in this experiment were leaf composition and grain yield. These variables were measured on plots arbitrarily selected to be four rows wide and thirty feet long. For 40" rows, this area of 13 1/3' by 30' is approximately 1/100 acre. The outside rows and five feet at the end of each plot were not harvested to eliminate any possible border effect. Thus, approximately 1/300 acre lay in the harvest area.

Factors to be considered in sampling plant tissue for chemical analyses are which plant part to sample, growth stage at which to sample, the number of plants to sample, and perhaps factors such as time of day and climatic conditions at time of sampling. Tyner and Webb (1946), Hanway (1962) and Hanway and Dumenil (1955) have all stressed these factors. Most investigations have indicated that the leaf below and opposite the primary ear shoot at or near silking gives the most interpretable information with respect to plant analysis and its objectives.

During the latter part of July and early August the number of silks which had emerged in each plot at each site were counted at least twice in order to obtain an accurate estimate of the date on which 75% of the plants had silked. Leaf samples were obtained from each plot of a given site on a day near the average 75% silking date for the entire site. These samples were dried and analyzed for total N, P and K contents.

It was impossible to sample each site at the same time of day, but each site was sampled at approximately the same average growth stage. Samples were collected from plants within the harvest area. Leaves were taken from plants which had 1/4" - 1" of silk showing. Fifteen plants per plot were sampled, which represented from 20-35% of the plants in the harvest area.

The leaf samples from each plot were dried and ground. One gram of each sample was digested in 20 ml. of conc. H_2SO_4. Total organic nitrogen was determined by steam distillation and titration procedures; total phosphorous was determined colorimetrically using molybdate-vanadate; and, total potassium was determined by flame photometer.

Plots were harvested when the plant reached physiological maturity. Twenty feet from each of the center two rows were harvested. The ears were weighed; two column of kernels were removed from each ear; these kernels were weighed, dried, reweighed and percent moisture calculated on the wet basis; grain yields were calculated at 15.5% moisture assuming a constant 80% shelling percentage for all plots. The latter assumption is not completely valid, however, and more accurate yield determinations would have resulted if all ears were shelled, and grain yield calculated from the grain weight only. This process would have required, however, many additional trips from Western Iowa to Ames where a suitable sheller was located. The error involved did not appear to be large enough to merit considerable additional expense and time. Compensations were made in the field for ears that were not completely filled with grain. All unfilled tips were broken off and discarded; ears with scattered filling were broken to approximate a small completely filled ear. For example, if an ear appeared to be one half filled, the ear was broken in half, one half was discarded, the other half weighed.

Percent barrenness was determined from the plants within the harvest area of each plot. The recorded population for the plot was also determined as a function of the plants within the harvest area. Since the harvest area was one third of the entire plot, the number of plants harvested should have been one third of those in the plot. More dense or more sparse stands within the harvest area would result in a biased relationship between plant population and fertility. Thus, the twenty feet from each of the middle two harvest rows was selected such that approximately one third of the plants in the plot were harvested.

Allocation of Applied Treatments to Plots Within the Population

With the objectives of the experiment clearly in mind and decisions made as to which factors to vary and which ones to eliminate as variables, the allocation of applied treatments to plots within the selected population, Marshall and Monona soils, can be accomplished.

Factors which must be considered in allocating treatments to plots and the selection of plot locations are 1) how many locations within the population are necessary to obtain the desired range for each of the uncontrolled factors; 2) what is the minimum number, if there is a minimum number, of plots necessary at each site; and 3) how many plots and/or sties will time, money and labor permit? A sufficient number of sites must be selected to cover the range of levels of each uncontrolled variable to be evaluated (eg. climate, cropping sequence, indigenous soil fertility, planting time, and soil yielding capacity). A sufficient number of treatments must be applied at each site to evaluate the rates of each controlled factor and interactions among the controlled factors at that level of the uncontrolled factors.

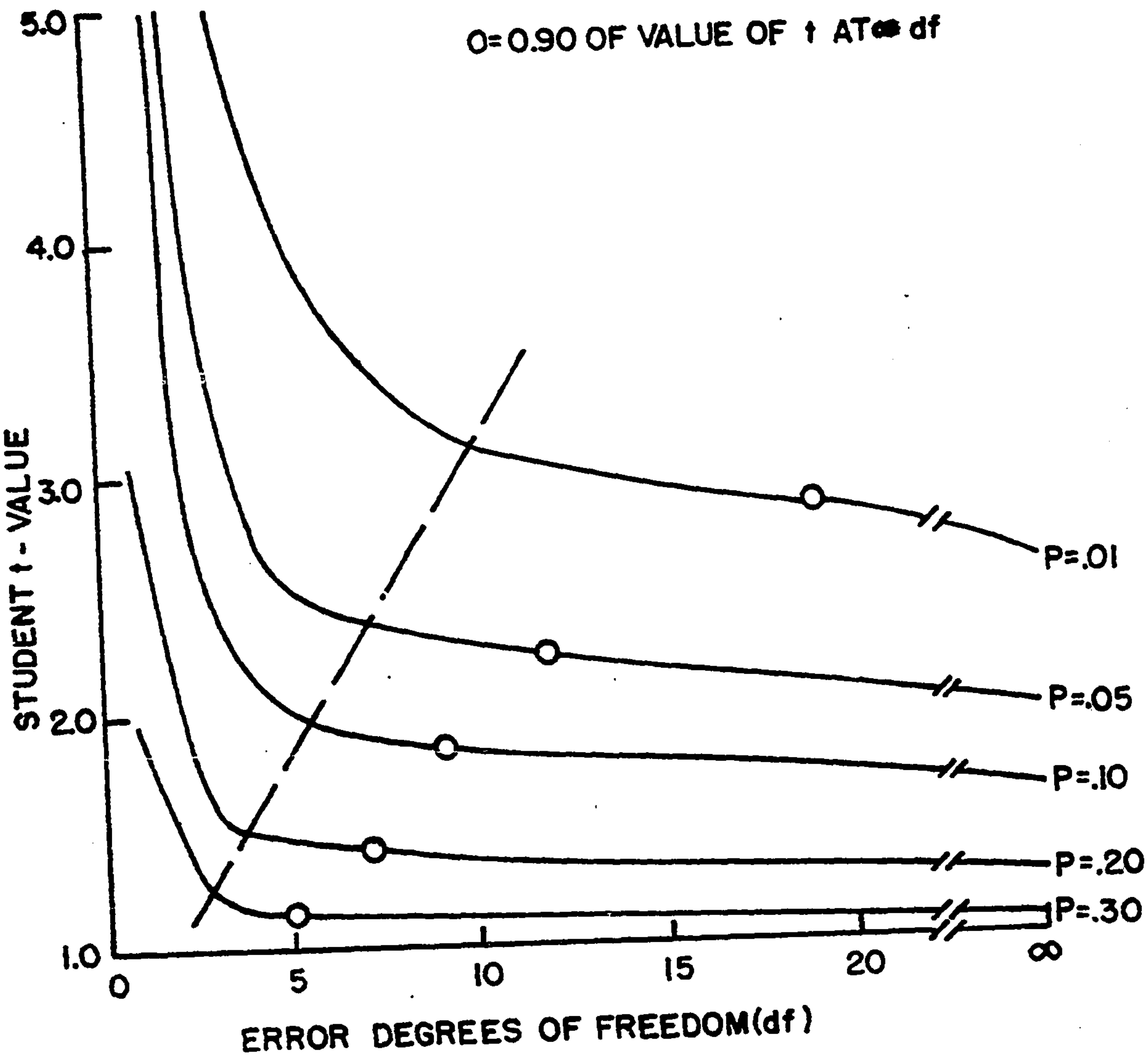
Using the above criteria the following approach was used. First, the minimum number of plots necessary at each site to provide a characterization of the controlled factors at a "constant" level of uncontrolled factors was determined. Secondly, the number of sites was chosen based on labor, time and money. A maximum range of uncontrolled variables was sought in selection of sites. This procedure may be backward since the objectives involved characterization of the population and not subsets (sites) of the population. This implies that the number of sites necessary should be determined first followed by the number of plots per site. But, because of the difficulty in determining the number of necessary sites, it was more convenient to determine the minimum number of necessary plots per site first, followed by determining the maximum number of sites permitted by economic factors.

Determination of minimum number of plots at each site

The minimum number of plots necessary at each site was determined from the criteria that 1) sufficient replication of applied fertilizer rates must be accomplished to provide a measure of experimental error (variation not explained by experimental measurements), 2) factor space coverage and allocation of treatment combination must give high precision on the measurement of intercept, linear, quadratic and interaction coefficients of a multiple regression quadratic equation and yet afford a maximum amount of orthogonality among these coefficients, and 3) a sufficient number of plots must be present at each site to test a regression equation of the nine fertilizer terms of a quadratic equation plus, at least, two additional terms which may be necessary to explain yield variability within the site.

The first criterion was met by an arbitrary decision that five to eight replicated treatments should provide an adequate measure of experimental error for a simple analysis of variance. The third criterion requires a decision as to how many degrees of freedom must be present for the error term. Figure 1 shows the relationship between Student's "t" and error degrees of freedom at various probability levels. The dashed line in Figure 2 connects points at which the relationship between the "significance point of t" and d.f. becomes nearly constant. That is, beyond this point

Figure 2. Relationship between Student's t-values and error degrees of freedom at several levels of probabilty


O= 0.90 OF VALUE OF t AT ∞ df
5.0
4.0
3.0
2.0
1.0
STUDENT t - VALUE
P=.01
P=.05
P=.10
P=.20
P=.30
0
5
10
15
20
∞
ERROR DEGREES OF FREEDOM(df)

additional plots would not contribute greatly to a reduction in the "significance point", and thus could be used more efficiently by establishing more sites. Consequently, ten to fifteen degrees of freedom should be sufficient to permit testing individual regression coefficients at the 5%, or even 1%, level of probability. A plot of F-values against degrees of freedom results in a similar figure. Thus, the total number of plots (degrees of freedom) necessary per site are 9 (fertilizer terms of a quadratic polynomial) + 1 (overall mean) + 2 or 3 (additional variables) + 10-15 (error) = 22-28, providing these treatment combinations (points) can be allocated in a manner to satisfy criterion no. 2, proper factor space coverage and precise measurement of coefficients.

Dr. Wayne Fuller, Iowa State University Professor of Statistics and Economics, provided a design which met all three criteria. In line with the central composite design terminology, this design is a "1 1/2 cube" with the "star points" replicated. The basic 1 1/2 cube contains 18 points. The star points, or treatments at the center of the six faces of a cube are replicated, and a center point was added, resulting in 25 plots per site. Table 6 lists the treatment levels, both coded and actual pounds of nutrient. The inverse of the coded values are listed in Appendix, Table 41a.

Table 6. Treatment levels and combinations in coded and actual values

Treatment number	Coded values			Actual values lbs./A			Coded values used in computer analysis		
	N	P	K	N	P	K	N	P	K
1	-2	-2	-2	0	0	0	-100	-30	-60
2	+2	+2	-2	200	60	0	+100	+30	-60
3	+2	-2	+2	200	0	120	+100	-30	+60
4	-2	+2	+2	0	60	120	-100	+30	+60
5	+1.913	+1.913	+1.913	195.6	58.7	117.4	+95.6	+28.7	+57.4
6	+1.913	-1.913	-1.913	195.6	1.3	2.6	+95.6	-28.7	-57.4
7	-1.913	+1.913	-1.913	4.4	58.7	2.6	-95.6	+28.7	-57.4
8	-1.913	-1.913	+1.913	4.4	1.3	117.4	-95.6	-28.7	+57.4
9	+1	+1	+1	150	45	90	+50	+15	+30
10	+1	-1	-1	150	15	30	+50	-15	-30
11	-1	+1	-1	50	45	30	-50	+15	-30
12	-1	-1	+1	50	15	90	-50	-15	+30
13	+2	0	0	200	30	60	+100	0	0
14	+2	0	0	200	30	60	+100	0	0
15	-2	0	0	0	30	60	-100	0	0
16	-2	0	0	0	30	60	-100	0	0
17	0	+2	0	100	60	60	0	+30	0
18	0	+2	0	100	60	60	0	+30	0
19	0	-2	0	100	0	60	0	-30	0
20	0	-2	0	100	0	60	0	-30	0
21	0	0	+2	100	30	120	0	0	+60
22	0	0	+2	100	30	120	0	0	+60
23	0	0	-2	100	30	0	0	0	-60
24	0	0	-2	100	30	0	0	0	-60
25	0	0	0	100	30	60	0	0	0

Determination of number of sites within the population

Estimation of labor requirements resulted in a decision that the desired applications and measurements could be satisfactorily accomplished at approximately 15 sites per year. Thus, in each of two years, sites were sought which would represent a range of each uncontrolled variable.

Comparison of various composite type designs

The efficiency of the 1 1/2 cube design in comparison with other commonly used designs is of importance. Table 7 lists the "adjusted" inverse matrices for the following designs: Box's original 15 point design, double cube with 23 points, triple cube with 31 points, and the 1 1/2 cube with 25 points. Adjustment was accomplished by multiplying the elements of the inverse matrix by the number of treatments in the design, as suggested by Box and described by Tramel (1956). It is observed that the 1 1/2 cube does not provide quite the precision of the double cube with respect to estimation of interaction coefficients but is clearly superior in estimation of quadratic coefficients. In addition, some replication is provided with the 25 treatments of the 1 1/2 cube in contrast to no replication with the 23 treatments of the double cube.

Table 7. Comparison of the precision of several central composite type designs

Element	N x inverse matrix: Box N=15	Triple cube N=31	Double cube N=23	1 1/2 cube N=25	Relative efficiency, %: Box	Triple cube	Double dube	1 1/2 cube
Var.-intercept	11.666655	3.340715	3.154611	3.543250	100	349	370	329
Var.-linear	0.937500	0.937500	0.479159	0.493848	100	100	196	190
Var.-quadratic	1.354170	0.994077	0.534129	0.329300	100	136	254	411
Var.-interactions	1.875000	0.749921	0.169119	0.205672	100	250	1100	912
Cov.-b_o x Q	-3.333333	-0.731507	-0.344126	-0.418552	100	456	970	796
Cov.-Q x Q	-0.885420	-0.154132	-0.184621	-0.661326	100	575	480	1444

RESULTS AND DISCUSSION

Soil Variability

Doubling sampling of five plots per site and subsequent splitting of each sample before chemical analyses provided the necessary replication to permit estimates of variability within a site and variability associated with sampling and with laboratory analyses. Analyses of variance for the five soil tests were calculated for each site. A pooled analysis of variance was also made to obtain a measure of pooled error mean square. The soil tests were soil pH, available phosphorous, exchangeable potassium, ammonifiable nitrogen and nitrifiable nitrogen.

For each site, 20 values per test were available for statistical analysis. The degrees of freedom for the respective sources of variation of systematic (true variation), sampling, laboratory, and sampling + laboratory (experimental error), were 4, 5, 10 and 15. Soil analyses were completed for 28 sites. Thus, a pooled AOV resulted in 139, 280, 420 degrees of freedom for plot, sampling, laboratory, and sampling + laboratory, respectively, for a total of 559 degrees of freedom for each laboratory test. In each case the significance of systematic variation was determined by an F-test, comparing systematic MS against MS for Sampling + Laboratory (EMS).

Analysis of variance revealed that the nitrate incubation test was considerably more precise than the ammonium incubation test. The pooled EMS for the NH_4^+ test was 120 in contrast to 104 for the NO_3^- test. (See Table 8). Regression analyses, which are discussed later, revealed, also, that the nitrate test was more highly correlated with yield and response to fertilizer than the ammonia test. For these reasons the use of "nitrogen soil test" or "soil nitrogen" terms will be in reference to the nitrate incubation soil test.

Analysis of variance at each site revealed that sampling error was consistently higher than laboratory error for all tests, with the possible exception of nitrogen. This was true for the nitrate incubation test, but the opposite was true for ammonium.

Tables 8a and 8b give some insight into variability within the sites. On the basis of AOV's at each of the 28 sites 10, 19, 26 and 19, of these sites showed significant (at 10% level) systematic variation for N, P, K and soil pH, respectively, based on F-ratios. Bartlett's test for homogeneity of variance using Chi-square revealed that the

Table 8a. Number of sites with significant variability in soil test values based on EMS of each site

Test	Level of significance, F-test					
	0.005	0.01	0.05	0.10	Total <0.10	Total >0.10
NH_4^+	2	1	2	1	6	21
NO_3^-	2	0	3	5	10	17
P	13	1	3	2	19	8
K	17	2	3	4	26	1
Soil pH	14	1	3	1	19	8

Table 8b. Number of sites with significant variability in soil test values based on pooled EMS

Test	F-ratio of plot variation MS / pooled MS						EMS
	5	4-5	3-4	2-3	Total >2	Total <2	
NH_4^+	0	0	0	0	0	27	120
NO_3^-	0	0	0	0	0	27	104
P	2	1	3	3	9	18	30.1
K	8	1	2	6	17	10	549
Soil pH	1	1	5	3	10	17	0.014

EMS's (laboratory + sampling errors) were not homogeneous from site to site. However, a pooled AOV was calculated, and the resultant EMS was used to test the systematic variation within each site. Table 9 lists the AOV for the respective tests, in addition to standard error and coefficient of variation. On this basis, only 0, 9, 17 and 10 of the 28 sites showed significant systematic variation for N, P, K and pH, respectively, based on an F-ratio of 2.0 or greater. If the pooled EMS is compared with the total variation among all 25 plots within each site, the number of sites with an F-ratio of 2.0 or greater were 0, 8, 19 and 6 for N, P, K and pH, respectively.

A further inspection of the various analyses of variance reveals that, based on EMS at each site, 2 of the sites varied in all four tests, 10 varied in three tests, 8 varied in two tests, 7 varied in one test, and only one site contained no significant systematic variation for any of the four soil tests. If the criteria are based on a pooled EMS and total variability of all 25 plots per site, the respective number of fits for 4, 3, 2, 1 and 0 tests being significant is 0, 4, 9, 9 and 6.

Regardless of the criteria used for determining the degree of systematic variation within an experimental site, it must be concluded that some of the sites did contain significant true variability, which was not detectable by any

Table 9. Pooled analysis of variance for soil test values

Source of variation	df	Nitrogen			Phosphorous			Potassium			Soil pH		
		MS	$\sqrt{MS}$	C.V.	MS	$\sqrt{MS}$	C.V.	MS	$\sqrt{MS}$	C.V.	MS	$\sqrt{MS}$	C.V.[a]
Systematic	139	874			1410			38400			1.025		
Sampling	140	202			64.6			1110			0.018		
Laboratory	280	52.4			12.7			265			0.012		
S+L error	420	104	10.2	15.8%	30.1	5.5	19.0%	549	23.4	9.0%	0.014	0.117	24.5%

[a]C.V. for soil pH determined from AOV of $[H^+]$ concentration.

method other than sampling on an individual plot basis. Therefore, justification for individual plot sampling and use of these data on a plot basis is substantiated.

Selection of a Weather Index

Two types of indices were investigated, each with one modification, in an attempt to relate meteorological conditions to corn yield and fertilizer response. The four indices, and their symbols which will be used in discussing them, were Dale's (1964) stress day-nonstress day concept (D_1), a quantification of this index to give a continuous nonstress index (D_2), Laing's (1966) relative photosynthesis index based on estimated relative turgidity (D_4), and Shaw's (1968) modification of this index (D_3). The primary criterion for evaluation of these four indices was how much variation in yield from site to site could be explained by each index. Thus, the simple correlation between each index and average yield at each site was determined. The average site yield was used since it was a manifestation of the site average of all factors which varied within each site. Figures 3a-3d show the actual values observed for each of the indices at each site, over a 63 day period from 6 weeks before to 3 weeks after the average silking date at each site, as well as equations fitted to each set of data.

Figure 3a. Relationship between Dale's stress index and average grain yield at each site

Solid dot = 1967 sites
Open dot = 1968 sites

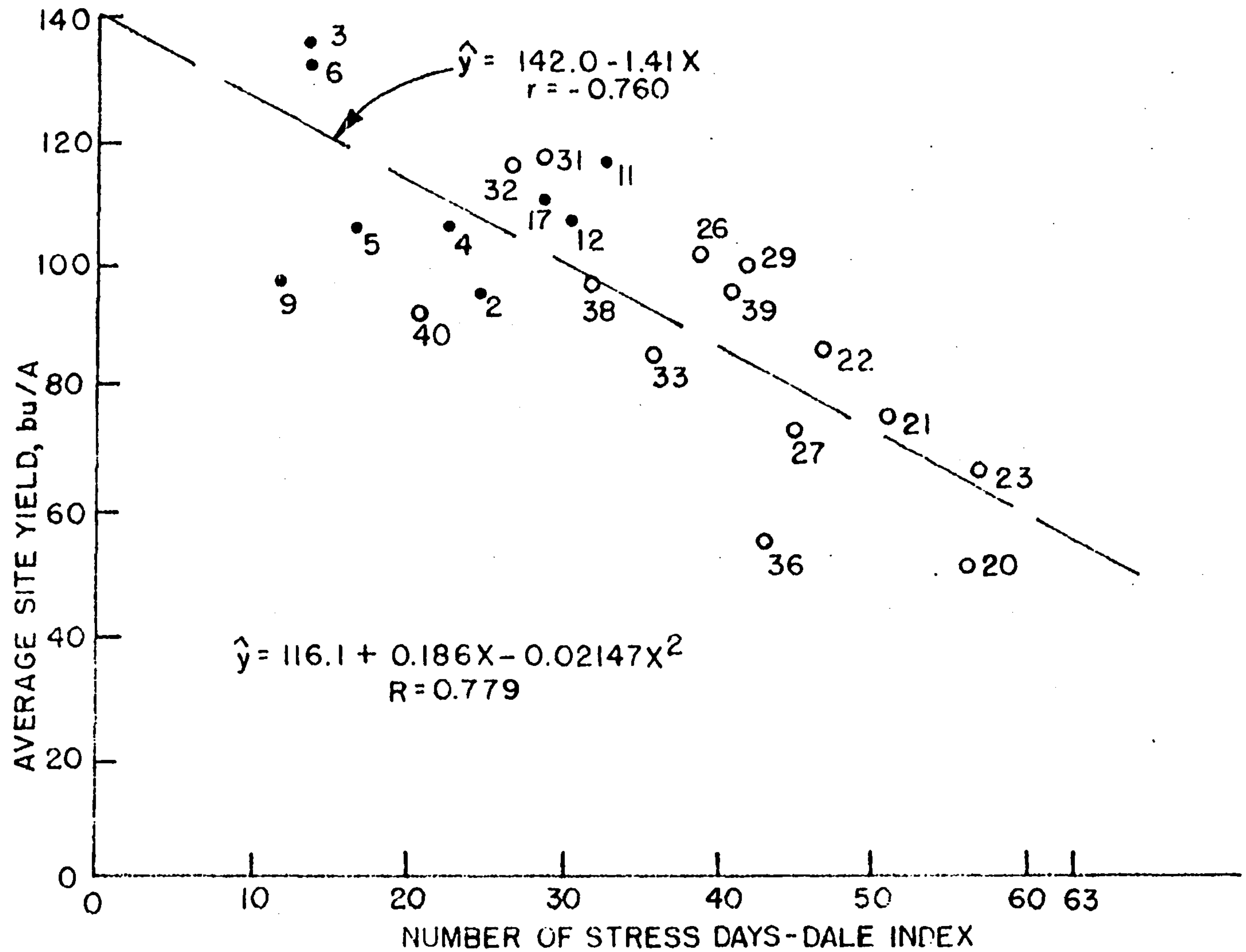
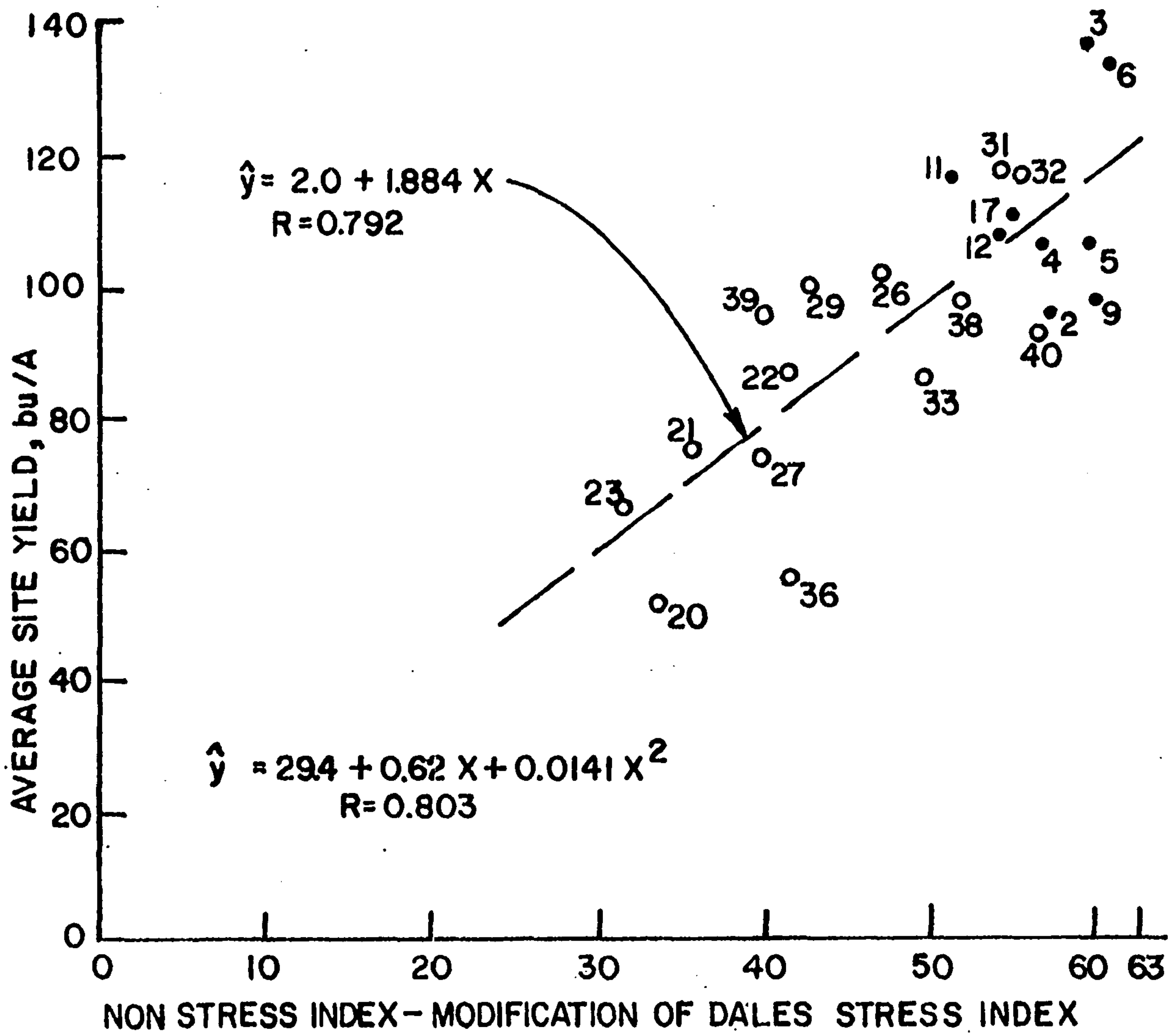

ŷ = 142.0 - 1.41X
r = - 0.760
ŷ = 116.1 + 0.186X - 0.02147X²
R = 0.779
AVERAGE SITE YIELD, bu/A
NUMBER OF STRESS DAYS-DALE INDEX
0
20
40
60
80
100
120
140
10
30
50
60
63
3
6
31
11
32
17
12
26
29
5
4
9
40
2
38
39
33
22
21
27
23
36
20

Figure 3b. Relationship between nonstress index and average grain yield at each site

Solid dot = 1967 sites
Open dot = 1968 sites



AVERAGE SITE YIELD, bu/A
NON STRESS INDEX – MODIFICATION OF DALES STRESS INDEX
ŷ = 2.0 + 1.884 X
R = 0.792
ŷ = 29.4 + 0.62 X + 0.0141 X²
R = 0.803
0
20
40
60
80
100
120
140
0
10
20
30
40
50
60
63
3
6
31
32
11
17
12
4
5
39
29
26
38
2
9
40
22
33
21
27
23
36
20

Figure 3c. Relationship between Laing's relative photosynthesis index and average grain yield at each site

Solid dot = 1967 sites
Open dot = 1968 sites

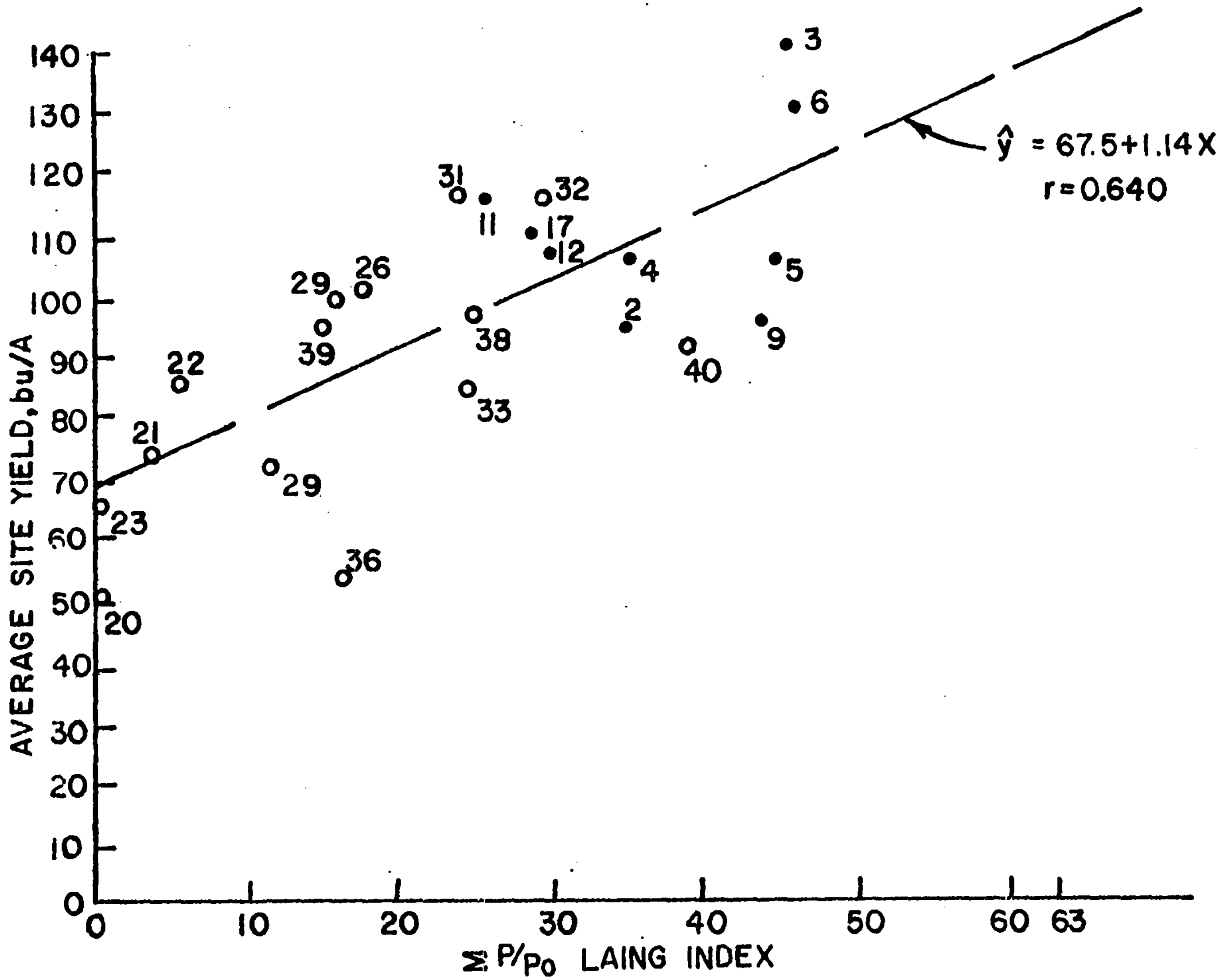
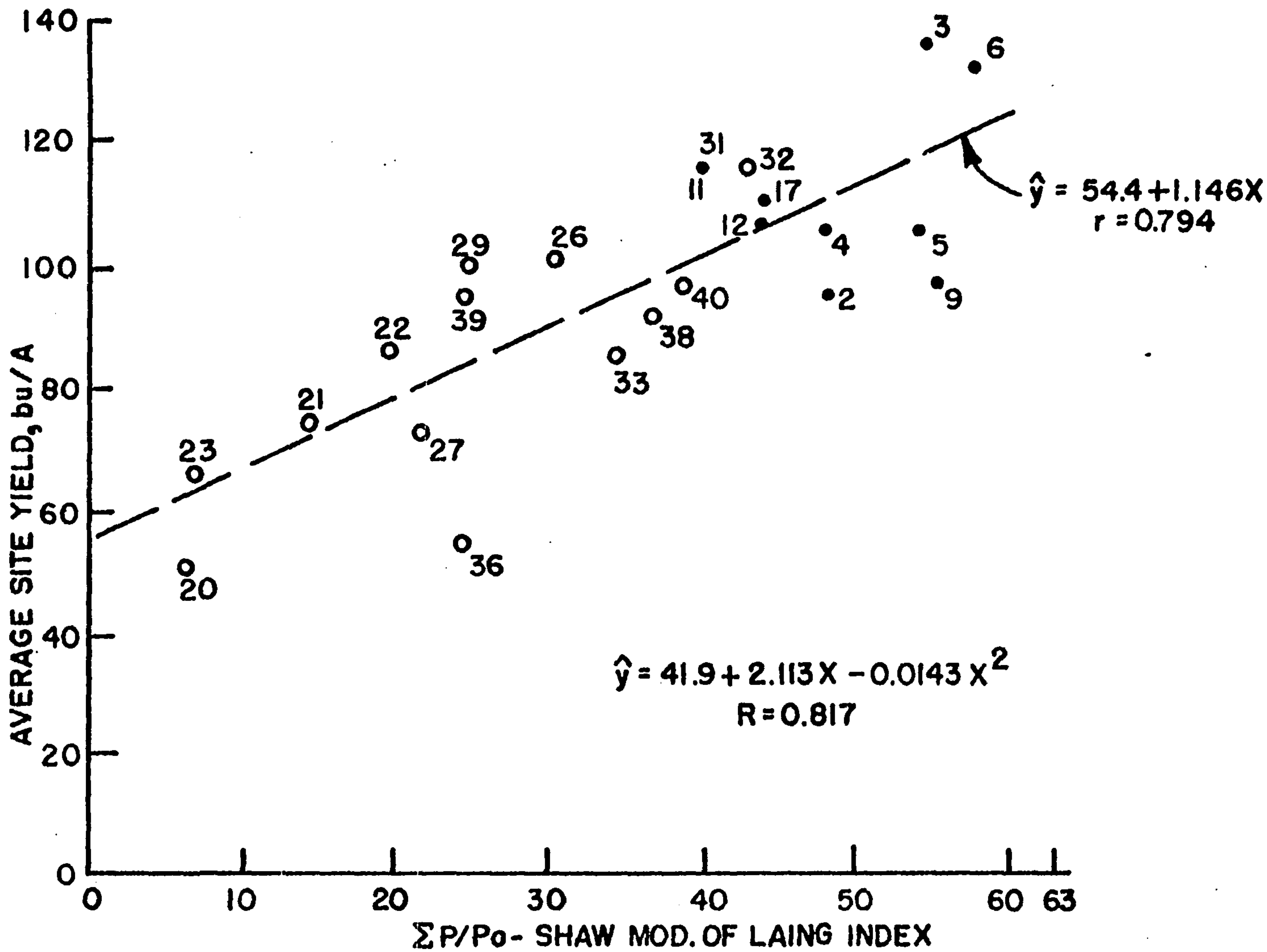

140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
AVERAGE SITE YIELD, bu/A
0
10
20
30
40
50
60
63
Σ P/Po LAING INDEX
ŷ = 67.5+1.14X
r=0.640
3
6
31
11
32
17
12
4
5
2
9
40
26
29
39
38
22
33
21
29
23
36
20

Figure 3d. Relationship between Shaw's modification of Laing's index and average grain yield at each site

Solid dot = 1967 sites
Open dot = 1968 sites



140
120
100
80
60
40
20
0
AVERAGE SITE YIELD, bu/A
0
10
20
30
40
50
60
63
ΣP/Po- SHAW MOD. OF LAING INDEX
3
6
31
11
32
17
12
4
5
2
9
29
26
39
40
22
38
33
21
23
27
20
36
ŷ = 54.4+1.146X
r = 0.794
ŷ = 41.9+2.113X −0.0143 X²
R=0.817

In 1967, the extent of weather variability was not large and correlations between indices and average yield were not high. In 1968, however, the range in values was much wider and generally complemented the values from 1967. Consequently, a more complete range in indices was observed than has been the case with most investigations. For example, a range from 12 to 57 stress days (D_1), during the 63 day period 6 weeks before and 3 weeks subsequent to silking, was observed in this investigation. Dale (1964) developed the stress day concept with a range in values from 11 to 61 during the 63 day period for the years 1933-1962. Desselle (1967) observed a range of 11 to 43 stress days during a 126 day period from planting to maturity. The respective ranges for D_2, D_3 and D_4 for this 63 day period in this study were 32-61, 7-57 and 0.5-46. For the 77 day period from 6 weeks before to 5 weeks after silking, the respective totals for D_1, D_2, D_3 and D_4 were 20-69, 40-74, 10-66, and 0.5-48.

The weather index which was selected as the one to be used in multiple regression models for explaining variability in yield and yield response was D_3, Shaw's modification of Laing's relative photosynthesis index. Several reasons for this selection included: 1) higher correlation, both from linear and quadratic equations, between D_3 and average yield than between other indices and average yield, as indicated in Figure 3, 2) greater range in values than other indices, and

3) cause and effect is more apparent in this index than in a simple stress index. The nonstress index, D_2, compared favorably with D_3 with respect to correlation with average yield. However, the range of values was not as wide, and it bears no direct relationship with the physiological processes which limit yield.

Subdividing the growing season into three periods, period I of 6 weeks before to 3 weeks before silking, Period II of 2 weeks before to 1 week after silking, and Period III of 2 weeks after to 5 weeks after silking was also investigated. The use of this partitioning of the growing season did not improve the correlation with yield. It did reveal that Periods I and II were approximately equal in their correlations with yield and considerable higher than Period III.

Yield Response

A characterization of corn yield response on Marshall and Monona soils was accomplished through a series of multiple regression models. First, each site was characterized in order to evaluate the controlled factors at each level of the uncontrolled factors. The resultant regression coefficients (RC) from each site were then compared and variability among the RC's calculated to determine the significant controlled-uncontrolled factor interactions. The final step was the combination of all sites into a multiple regression equation which contained the significant controlled and uncontrolled factors and their interactions.

Of the 13 sites which were established in 1967, the results from only 9 were analyzed. Three sites received excessive hail and a fourth site contained subsurface gravel lenses which resulted in excessive soil moisture variability for which no measure was available. Of the 17 sites established in 1968, only 14 were analyzed. One site was victimized by the cooperator's sheep, who ate all top growth early in the season, and two sites were drouthy to the extent that approximately 80 percent of all plants were barren, thus rendering the influence of all other factors undeterminable. Thus, the data from 23 sites, 575 plots, were used in estimating yield response. Of these 23 sites, 10 were on Marshall soils and 13 on Monona soils.

Characterization of individual sites

The following quadratic polynomial was fitted to the yields and applied treatments at each site:

$$Y = b_o + b_1N + b_2N^2 + b_3P + b_4P^2 + b_5K + b_6K^2 + b_7NP + b_8NK + b_9PK \qquad (1)$$

This expression will be referred to as Equation 1 subsequently in the text. The fertilizer treatments were entered into the computer as coded values as given in Table 6. The mean treatment levels of N, P and K were all assigned the value of zero. This enabled complete orthogonality (independence) among linear terms and between linear and quadratic terms but not complete orthogonality between linear and interaction terms or among quadratic terms. As a result of coding around zero and nearly 100% independence among terms, the regression constant, b_o, is a close approximation of the mean Y value of the experiment but not an exact mean. Equation 1 satisfactorily accounted for yield variability within a site at some of the sites, based on R^2, (multiple correlation) values. However, at many sites it was obvious that all other factors were not uniform within the site. Uncontrolled factors which appeared to vary considerably within one or more of the sites included plant population (S), weed growth (W), barrenness (B), root size (RS), root damage (RD), soil yielding potential (C), and soil moisture (H). Consequently, at those sites where a particular uncontrolled factor varied within a site, expanded equations were fitted in an attempt to characterize each site and to minimize the standard error for yield determination. Table 10 lists the eleven different equations which were used and Table 11 the average resultant R^2 increase and standard error decrease which resulted from each of the expanded equations in comparison with Equation 1.

Table 10. Multiple regression models used in characterizing yields at each site

Equation number	Variables[a]
1	$Y = f(N, N^2, P, P^2, K, K^2, NP, NK, PK)$
2	$Y = f(\quad ,B_A)$
3	$Y = f(\quad ,S)$
4	$Y = f(\quad ,RD)$
5	$Y = f(\quad ,RS)$
6	$Y = f(\quad ,B_A, RD)$
7	$Y = f(\quad ,W)$
8	$Y = f(\quad ,S, B_A)$
9	$Y = f(\quad ,B_A, C)$
10	$Y = f(\quad ,H)$
11	$Y = f(\quad ,B_A, H)$

[a] B_A = adjusted barrenness, %
S = plant population, 1000's per acre
RD = root damage rating
RS = root size rating
W = weed infestation rating
C = soil yielding potential, bu/A
H = soil moisture rating.

Table 11. Multiple correlations and standard errors resulting from various multiple regression models at each site

Equation number	02		03		04		05		06	
	R^2	s^2	R^2	s^2	R^2	s^2	R^2	s^2	R^2	s^2
1	0.553	15.1	0.338	14.5	0.521	13.4	0.833	9.6	0.567	9.6
2	0.863	8.7			0.763	9.8	0.841	9.7		
3									0.616	9.3
4	0.783	10.9	0.422	13.9	0.750	10.0	0.846	9.5		
5	0.636	14.1	0.379	14.4	0.597	12.8	0.833	9.9		
6	0.921	6.9								
7										
8										
9										
10										
11										

Equation number	09		11		12		17		20	
	R^2	s^2	R^2	s^2	R^2	s^2	R^2	s^2	R^2	s^2
1	0.811	8.5	0.444	11.0	0.632	8.9	0.569	13.7	0.286	14.8
2					0.665	8.7			0.729	9.4
3										
4					0.695	8.3			0.286	15.2
5					0.729	7.9				
6										
7			0.809	6.7						
8										
9							0.868	8.1		
10										
11										

Table 11. (Continued)

Equation number	21 R^2	21 s^2	22 R^2	22 s^2	23 R^2	23 s^2	26 R^2	26 s^2	27 R^2	27 s^2
1	0.332	13.1	0.297	14.9	0.514	8.9	0.576	6.0	0.356	9.1
2	0.436	12.4	0.620	11.3	0.676	7.5	0.576	6.1	0.478	8.4
3							0.681	5.3		
4	0.353	13.3	0.301	15.3						
5										
6										
7										
8									0.580	7.8
9										
10										
11										

Equation number	29 R^2	29 s^2	31 R^2	31 s^2	32 R^2	32 s^2	33 R^2	33 s^2	36 R^2	36 s^2
1	0.192	11.1	0.416	9.3	0.387	8.8	0.334	8.0	0.385	6.6
2	0.198	11.4	0.538	8.5	0.491	8.3	0.595	6.4	0.385	6.8
3	0.318	10.5							0.396	6.7
4										
5										
6										
7										
8			0.807	5.7	0.706	6.5				
9										
10										
11										

Table 11. (Continued)

Equation number	38 R^2	38 s^2	39 R^2	39 s^2	40 R^2	40 s^2	Average change from Equation 1 R^2	s^2	No. of sites
1	0.593	10.3	0.402	18.0	0.391	20.0	0	0	23
2	0.646	9.9	0.899	7.6	0.405	20.3	+.156	-1.9	18
3			0.404	18.5			+.059	-0.2	5
4	0.595	10.6	0.405	18.5			+.066	-0.7	10
5							+.061	-0.5	5
6							+.368	-8.1	1
7							+.365	-4.3	1
8	0.681	9.7	0.915	7.2			+.307	-3.7	5
9							+.299	-5.6	1
10			0.729		0.729	13.7	+.338	-6.3	1
11					0.770	13.1	+.379	-6.9	1

At a large number of the sites, barrenness was a significant factor. In an attempt to remove the influence of treatment or some site related variable from the effect of barrenness on yield, an adjusted barrenness value was calculated for each plot by substracting from the measured barrenness the average barrenness over all sites for that treatment and the average barrenness of that site over all barrenness mean for all plots at all sites. That is B_A = $B_{ij} - B_{i\cdot} - B_{\cdot j} + B_{\cdot\cdot}$. The use of the adjusted barrenness factor significantly increased the R^2 and decreased the standard errors at eleven sites, as shown by comparison of the results for Equations 1 and 2 in Table 11. The use of stand alone as a covariate, Equation 3, was significant at only two sites, but stand plus barrenness, Equation 8, provided large changes in R^2 and standard error at three additional sites, No. 31, No. 32 and No. 39.

In 1967, unsatisfactory rootworm control was obtained on many plots which were corn after corn and, thus, the use of root ratings improved the multiple correlation and standard error values at sites 02, 04, and 12. Root damage was superior to root size ratings in explaining yield variation. In 1968, insecticide treatment resulted in nearly complete control of rootworms.

At one site (No. 11) the use of a weed infestation variable increased the R^2 from 0.44 to 0.81 and decreased the standard error from 11.0 to 6.7 bushels per acre. At one site (No. 17) where some of the plots were located on Monona and others on Ida soil, the use of a soil yielding potential variable, in addition to barrenness, increased R^2 from 0.57

to 0.87 and decreased the standard error for 13.7 to 8.1 bushels per acre.

One site in 1968 (No. 40) lay between two terraces. Striking soil moisture differences became obvious during the growing season and could be related to surface topography. Thus, a dummy moisture variable, a rating of 1, 2, 3, or 4, was used. The use of this variable increased R^2 from 0.39 to 0.73 and decreased the standard error from 20.0 to 13.7 bushels per acre.

At sites where the uncontrolled factors acted as covariates, that is did not interact with treatment, the regression coefficients for fertilizer variables which resulted from fitting the appropriate expanded equation were used in comparing responses among sites. These statistics are recorded in Table 12.

Analysis of variance tables for each site as recorded in Table 12 reveal that only 11 of the 23 sites, 7 of 9 in 1967 and 4 of 14 in 1968, had overall fertilizer treatment effects significant at the 30% level, using Equation 1. Of these, 7 were significant at the 10% level. However, with the use of 1 or 2 covariates at 21 of the sites, in addition to the fertilizer terms of Equation 1, 19 of the 23 sites, 8 of 9 in 1967 and 11 of 14 in 1968, had F-ratios significant at the 30% probability level. Of these, 18 were significant at the 10% level.

Table 12. Analysis of variance of yield for each experimental site

	AOV for equation 1				AOV for selected equation from Table 10				
	Degrees of freedom		Mean squares[a]		Degrees of freedom			Mean squares[a]	
Site no.	Reg'n (Trt)	Residual (Error)	Reg'n	Residual	Eq. no.	Reg'n (Trt)	Residual (Error)	Reg'n (Trt)	Residual (Error)
02	9	15	472.31++	229.23	6	11	13	643.46***	47.02
03	9	15	170.84	209.74	4	10	14	197.62	193.39
04	9	15	303.81++	179.59	2	10	14	400.23**	95.86
05	9	15	765.88***	91.87	1	9	15	765.88**	91.87
06	9	15	198.43+++	91.35	3	10	14	194.50+++	86.52
09	9	15	580.94***	72.39	1	9	15	580.94***	72.39
11	9	15	149.58	120.45	7	10	14	245.31***	44.58
12	9	15	224.23*	78.47	5	10	14	233.01*	61.79
[illegible]	9	15	412.52+++	187.34	9	11	13	514.89***	66.07
20	9	15	164.58	217.84	2	10	14	377.75***	87.94
21	9	15	161.22	171.57	2	10	14	190.57	153.88
22	9	15	176.83	221.37	2	10	14	331.81*	127.29
23	9	15	159.02++	79.59	2	10	14	188.18*	56.40
26	9	15	90.89+++	35.45	3	10	14	96.72*	28.35
27	9	15	85.88	82.31	8	11	13	114.58++	60.79
29	9	15	55.06	122.26	3	10	14	81.97	109.65
31	9	15	116.53+	86.76	8	11	13	185.26***	32.39
32	9	15	92.71	77.66	8	11	13	138.23*	42.27
33	9	15	60.93	64.27	2	10	14	97.70+++	41.50
36	9	15	51.57	43.63	3	10	14	47.70	45.55
38	9	15	290.40*	105.35	8	11	14	272.56*	93.76
39	9	15	409.44	322.56	8	11	14	762.29***	52.22
40	9	15	484.36	398.77	11	11	14	780.05***	170.51

[a]The symbols indicating significance level will be used throughout this thesis as follows: *** = 0.001 prob. level for t-test (0.005 prob. level for F-test); ** = 0.01 prob. level; * = 0.05 prob. level; +++ = 0.10 prob. level; ++ = 0.20 prob. level; + = 0.30 prob. level.

A closer examination of the individual regression coefficients for each fertilizer term, listed in Table 13, reveals a wide variation in the type of response among sites, reflecting interactions among fertilizer and certain uncontrolled variables. Sixteen sites had positive and significant (at the 30% level) responses to nitrogen as indicated by the linear coefficient. One site had a negative linear coefficient significant at the 30% level. The other six sites had nonsignificant positive coefficients. Nitrogen response generally decreased with higher rates as indicated by 11 negative and significant coefficients to the quadratic term. However, five sites exhibited increased response at higher rates. Of the seven nonsignificant quadratic coefficients, five were positive and two negative.

Phosphorous response was positive and significant, at the 30% level, at 9 sites, significant and negative at 1 site, and nonsignificant at the remaining 13 sites, as indicated by the regression coefficients of the linear term. Of the nonsignificant coefficients, 7 were positive and 6 negative. Five sites decreased significantly in response at higher rates, 1 responded more at higher rates and 1 decreased in yield less rapidly as phosphorous fertilization rate increased. The other 16 quadratic terms were nonsignificant.

Table 13. Regression coefficients and R^2-values obtained from fitting a second degree polynomial with interactions to corn yield data from each site

Regression coefficient	Site number 02	03	04[a]	05
b_o	102.5261***	137.7326***	110.5269***	106.4550***
b_1 (N)	+0.14200**	+0.05667++	+0.10324**	+0.20017***
b_2 (N)	-0.00152+++	+0.00034	-0.00072++	-0.00112*
b_3 (P)	+0.03863	+0.19104++	+0.83050	+0.03611
b_4 (P^2)	+0.00308	-0.00924+	+0.00097	-0.00021
b_5 (K)	-0.05349	-0.02132	-0.09743+++	-0.05160+
b_6 (K^2)	-0.00145	-0.00012	-0.00259+++	+0.00218+++
b_7 (NP)	+0.00019	+0.00178	-0.00085	+0.00067
b_8 (NK)	+0.00094	-0.00021	+0.00044	+0.00187**
b_9 (PK)	+0.00187	+0.00271	-0.00121	-0.00199
R^2	0.553	0.328	0.763	0.833
	06	09	11[a]	12
b_o	136.6831***	101.3253***	113.8611***	104.7390***
b_1	+0.07039*	+0.14784***	+0.01181	+0.08121**
b_2	-0.00077++	-0.00070+++	-0.00370+	-0.00112*
b_3	+0.11269+	+0.34631***	-0.32960	+0.09744+
b_4	-0.00193	-0.00629++	-0.00221	+0.00849+++
b_5	+0.06825++	-0.10289*	+0.02447	+0.01191
b_6	-0.00021	+0.00070	+0.00065	+0.00154++
b_7	-0.00026	+0.00101	-0.00082	+0.00083
b_8	+0.00128*	+0.00103++	-0.00019	+0.00021
b_9	+0.00214	+0.00056	+0.00043	+0.00071
R^2	0.567	0.811	0.809	0.632
	17[a]	20[a]	21[a]	22[a]
b_o	112.5075***	47.4613***	64.5974***	81.8017***
b_1	+0.14638***	+0.03588+	+0.01919	+0.02337
b_2	-0.00160	-0.00015	+0.00062+	+0.00029
b_3	+0.09744+	-0.00784	+0.00691	-0.09499
b_4	-0.00771+++	+0.00525+	-0.00013	+0.00390
b_5	+0.1680	+0.00078	-0.04783	-0.03435
b_6	+0.00422**	-0.00004	+0.00180+	+0.00063
b_7	-0.00229+++	+0.00143+	-0.00013	-0.00167+
b_8	-0.00129*	-0.00008	-0.00111++	-0.00174*
b_9	+0.00054	-0.00306++	+0.00210	+0.00058
R^2	0.868	0.729	0.436	0.620

[a]These equations correspond to the selected equations as indicated in Table 12.

Table 13. (Continued)

Regression coefficient	Site number			
	23[a]	26[a]	27[a]	29
b_0	72.8189***	94.4039***	77.0667***	95.5384***
b_1	-0.02755+	+0.00042	+0.04573+++	+0.00997
b_2	+0.00014	+0.00051+++	-0.00060+++	+0.00068+
b_3	+0.19050*	-0.15305**	+0.04434	-0.06813
b_4	-0.00743++	-0.00054	+0.00098	-0.00458
b_5	-0.02966	+0.00464	+0.01735	+0.00525
b_6	-0.00103	+0.00156+++	-0.00010	+0.00086
b_7	+0.00121+	-0.00060	-0.00018	-0.00009
b_8	-0.00114*	-0.00006+++	-0.00031	+0.00042
b_9	+0.00141	-0.00192+++	-0.00120	-0.00128
R^2	0.676	0.681	-.478	0.192
	31[a]	32[a]	33[a]	36
b_0	117.3625***	116.5855***	85.0281***	53.0709***
b_1	+0.04064	+0.05355*	+0.04114*	+0.02091
b_2	+0.00011	-0.00008	+0.00046++	+0.00033
b_3	-0.00459	+0.00933	+0.13235*	-0.01041
b_4	+0.00042	-0.00010	-0.00202	-0.00760*
b_5	+0.00525	+0.0094	+0.03508	+0.00071
b_6	-0.00118++	-0.00043	-0.00167+++	+0.00106+
b_7	+0.00136+++	+0.00091	+0.00061	-0.00024
b_8	+0.00054++	+0.00031	+0.00074+++	-0.00022
b_9	+0.00177++	+0.00026	-0.00159+	+0.00218
R^2	0.807	0.491	0.595	0.385
	38	39	40[a]	
b_0	104.3251***	96.7483***	98.2251***	
b_1	+0.08989**	+0.03333	+0.10032*	
b_2	-0.00082+++	+0.00039	-0.00156*	
b_3	+0.10657+	+0.42264*	+0.07657	
b_4	-0.00137	-0.00663	-0.00483	
b_5	-0.11348*	-0.09658+	-0.02628	
b_6	-0.00193++	-0.00073	-0.00141	
b_7	-0.00037	-0.00208	-0.00016	
b_8	+0.00014	+0.00097	-0.00118++	
b_9	+0.00070	+0.00461+	-0.00047	
R^2	0.593	0.402	0.729	

Potassium response was generally nonsignificant and quite erratic, but 6 of the sites exhibited a significant negative response. Only one site responded in a significant and positive direction. Of the 16 sites which did not express a significant linear effect, 10 had positive regression coefficients and 6 had negative. Ten of the sites exhibited significant quadratic terms. Four of these were positive coefficients associated with positive linear coefficients, indicating increased positive response at higher rates; three were negative coefficients associated with negative linear coefficients, indicating increased negative response at higher rates; two were positive coefficients associated with negative linear coefficients, indicating decreased negative response at higher rates; and only one was a negative coefficient associated with a positive linear coefficient, indicating decreased positive response at higher rates.

Interactions among the applied fertilizers were generally nonsignificant and inconclusive. Five sites exhibited a significant NP interaction, 3 positive and 2 negative. Of the nonsignificant coefficients, 10 were negative and 8 positive. Eleven NK coefficients were significant, but once again not consistent in direction. Five were significant and positive, and six were significant and negative. Of the nonsignificant coefficients, 7 were positive and 5 were negative. Seven PK coefficients were significant, 4 positive and 3 negative. Of the nonsignificant coefficients, 11 were positive and 5 negative.

Table 14 summarizes the degree of significance of each fertilizer statistic based on regression equations at each site.

Variation in response among sites

It has already been mentioned that the response to fertilizer was not consistent from site to site. This means that the response to fertilizer was influenced by factors which varied among these sites. To determine which specific interactions were involved, a three step procedure was followed. First, the variability of regression coefficients (RC's) of Equation 1, page 72, and listed in Table 13, was tested against pooled error mean squares to determine which RC's varied from site to site. Second, a correlation matrix was computed which indicated the relationship among the RC's listed in Table 13 and all uncontrolled factors. A t-test was used to test the significance of simple correlations between RC's of Equation 1 and the various uncontrolled factors. Third, the success with which uncontrolled factors were identified and measured was determined by regressing the average yield of each site against selected uncontrolled factors and inspecting the resultant R^2, multiple correlation. In addition, selected models of each fertilizer RC as a

Table 14. Number of sites in which coefficients of fertilizer variables were significant[a]

Variable	Level of probability, percent 0.1	1	5	10	20	30	Total number sig.	Number non-sig.
+N	3	4	5	1	1	2	16	6
-N						1	1	0
$+N^2$				1	1	3	5	5
$-N^2$	1		3	3	3	1	11	2
+P	1		3	1	1	3	9	7
-P		1					1	6
$+P^2$				1		1	2	5
$-P^2$			1	1	2	1	5	11
+K					1		1	10
-K			3	1		2	6	6
$+K^2$		1		2	1	2	6	4
$-K^2$				2	2		4	9
+NP				1		2	3	8
-NP				1		1	2	10
+NK		1	1	1	2		5	7
-NK			3	1	2		6	5
+PK					2	2	4	11
-PK				1	1	1	3	5

[a]Significance determined by Student's t-test, $t = b/s_b$.

function of uncontrolled factors were tested to determine how much of the variability in response could be accounted for by the uncontrolled variables. Models were selected for only those RC's which significantly varied from site to site.

Before the variability of RC's could be determined, the error in measurement of each RC had to be calculated. The estimated variance of any given RC, or b_i, is defined as

$$s^2_{b_i} = s^2 C_{ii} , \qquad (2)$$

where s^2 is the variance of Y, the dependent variable, and C_{ii} is the appropriate variance element from the inverse of the XX' matrix. The XX' matrix is, of course, the sums of products and cross products of the independent variables, in this case the applied fertilizer treatments, their quadratic and interaction terms. The inverse of the 1 1/2 cube design is listed in the Appendix A, Table 41a.

The variance of Y, s^2, was determined by pooling the individual sums of squares from individual sites. Bartlett's test for homogeneity of variance, utilizing Chi-square, revealed that these individual s^2 were heterogeneous. However, by using analysis of covariance, s^2 was sufficiently reduced at several sites to permit the pooling of more homogeneous variances. The variances at each site, based on the 6 treatments which were replicated at each site, are given in Table 15. The resultant pooled error mean square was approximately 87.4 bushels per acre. Thus, $s^2_{b_i} = 87.4\ C_{ii}$.

Table 15. Variances of yield at each individual site based on replicated treatments

1967 Site	1967 EMS, bu/A	1968 Site	1968 EMS, bu/A
02	67.2	20	85.1
03	63.7	21	169.9
04	115.3	22	112.0
05	62.2	23	102.8
06	53.1	26	32.2
09	59.2	27	96.0
11	130.2	29	167.0
12	84.1	31	55.6
17	167.5	32	48.1
		33	17.7
		36	26.3
		38	128.5
		39	69.0
		40	103.4
Pooled	89.2	Pooled	86.7
C.V.	8.4%	C.V.	11.1%

Total pooled 87.4

This variance, $s^2_{b_i}$, represents the error in measuring the respective RC's, or the within-site variation.

An AOV computation of each RC among the 23 sites provided the measure of among site variation. Thus an F-test was used to compare these two variances, as follows:

$$F = \frac{\text{among-site variation}}{\text{within-site variation}} \quad . \tag{3}$$

Table 16 lists the two above mentioned Mean Squares for each of the nine estimated fertilizer RC's and the resultant F-ratios. Of the nine, only six appeared to vary appreciable from site to site. Thus, few, if any, interactions between the other three and uncontrolled variables would be expected. The six RC's which did vary significantly from site to site were b_N, $b_N{}^2$, b_P, b_K, b_K2, and b_{NK}.

The factors which varied more among sites than within sites are listed in Table 17. All nine fertilizer coefficients were entered into the correlation matrix, despite the nonsignificant F-ratios of three of the RC's.

The possible significant interactions among the fertilizer coefficients, or response to fertilizer, and uncontrolled factors are listed in Table 18. These interactions were chosen based on the value of the simple correlation. Only the main effect factors are listed, and the significance level used was 0.10. The linear response to nitrogen was correlated with

Table 16. Among-sites Mean Squares, pooled within-site estimated variances and corresponding F-ratios for the calculated regression coefficients

Variable	Among sites df	Among sites Mean Square	Within site df	Within site Mean Square	F-ratio
	22		166		
b_N		.0029362204		.0006750000	4.35***
b_N^2		.0000005876		.0000001825	3.22***
b_P		.0165043779		.0075000000	2.20***
b_P^2		.0000239307		.0000220000	1.09
b_K		.0023490583		.0018750000	1.25++
b_K^2		.000030753		.000013875	2.22***
b_{NP}		.0000010571		.0000012850	0.82
b_{NK}		.0000007865		.0000003250	2.42***
b_{PK}		.0000035910		.0000035750	1.00

past cropping system, planting time, weed infestation, subsoil nitrogen, soil pH, subsoil pH, and all three stress indices. The direction of some of the correlations is opposite from what is usually observed. The correlation with date of planting is positive. This arises from the fact that in 1967, farmers were unable to plant until May 10-20 while in 1968, planting was accomplished from May 1-10.

Table 17. Fertilizer regression coefficients, factors which varied more among sites than within sites, and their correlations with average site yield.

Factor	Simple correlation, r	Factor	Simple correlation, r
b_N	0.27+	Ave. stand, S	-0.21
b_N^2	-0.23	Ave. barren, B	-0.50*
b_P	0.12	R^2	-0.05
b_P^2	-0.09	T^2	0.34++
b_K	0.18	W^2	0.11
b_K^2	-0.11	n^2	0.15
b_{NP}	0.13	p^2	-0.10
b_{PK}	-0.28+	k^2	0.00
b_{NK}	0.01	a^2	-0.00
Rotation, R	0.22	np	0.02
Plant. Date, T	0.38+++	nk	0.03
Soil yield potential, C	0.03	na	0.15
Weeds, W	0.17	pa	-0.04
Soil N, n	0.15	D_1^2	-0.78***
Soil P, p	-0.05	D_2	0.80
Soil K, k	-0.02	D_3	0.71***
Soil pH, a	-0.00	S^2	-0.24
Subsoil N, n_s	0.15	B^2	-0.46*
Subsoil P, p_s	-0.02	TD_3	0.55*
Subsoil K, k_s	0.03	SD_3	0.74***
Subsoil pH, a_s	0.07	CS	-0.17
Total stress days, D_1	-0.76***	Check plot yield, Y_o	0.95***
Nonstress index, D_2	0.79***	Relative PS, D_3	0.79***

Table 18. Selected interactions between fertilizer coefficients and uncontrolled factors based on simple correlation values which were significant at 10% probability level

Interaction	r[a]	Interaction	r[a]
RN[b]	0.40	WP	0.53
TN	0.54	pP	-0.40
WN	0.32	P_sP	-0.47
n_sN	0.43	pP^2	0.39
aN	0.39	RK	-0.40
a_sN	0.33	aK^2	0.45
D_1N	-0.67	a_sK^2	0.50
D_2N	0.66	SK^2	-0.50
D_3N	0.67	nNK	-0.43
RN^2	-0.38	D1NK	-0.63
TN^2	-0.42	D_2NK	0.57
CN^2	0.36	D_3NK	0.60
D_1N^2	0.53	k_sPK	0.40
D_2N^2	-0.57	D_1T	-0.55
D_3N^2	-0.58	D_2T	0.54
		D_3T	0.57

[a]r indicates simple correlation between the two factors listed in the interaction.

[b]Symbols of N, P, ..., in this table only, indicate response to applied fertilizer as estimated by Equation 1.

Moisture in 1967 was generally favorable, in contrast to 1968, and the average resultant yield was 110 bushels per acre in 1967 and only 85 bushels per acre in 1968. Response to nitrogen was generally much larger in 1967. Thus, the positive correlation. This is reflected also in the significant correlation between stress and planting date. Within each year, the correlation between response to N and planting date was negative and nonsignificant. For this reason, TN was not considered for the final equation. The positive correlation with weed infestation is similar. Weed control was more complete in 1968 than 1967 while yields were greater in 1967. Thus, the positive correlation between weed infestation and response to nitrogen. This interaction was not considered for the final equation either. The most significant correlation with nitrogen response is moisture stress. All three stress indices were highly correlated with nitrogen response. The quadratic nitrogen response coefficient was correlated with essentially the same factors as the linear coefficient.

The response to phosphorous was negatively correlated with both surface and subsoil phosphorous, indicating substitution. This provides justification for determining fertilizer phosphorous requirements based on soil test data. The quadratic phosphorous term was also affected by soil phosphorous.

Response to potassium seemed to be correlated with past cropping system, the farther away from meadow the less response to potassium. The erratic response to potassium does not appear to be clearly explained by the uncontrolled variables which were measured. The quadratic term was correlated with soil pH and plant population.

The only fertilizer interaction term which varied from site to site was NK, which apparently was a reflection on the influence of stress. The NK interaction was greater under conditions of less stress.

The average yield at each site was regressed on the other uncontrolled variables, in addition to the weather indices which were discussed previously, to determine the degree of variability which was explained by these uncontrolled variables. The average yield was used because it is the manifestation of the average levels of all uncontrolled and controlled variables within each site. Voss (1962) and Desselle (1967) used check plot yields rather than average yield for similar correlation. They were able to better characterize inherent fertility influences but were unable to regard response to fertilizer in their characterization. The precision with which average yield is measured is much greater than check plot yield because of the much larger number of plots involved.

The successive models, the resultant R^2 and the significance of each RC of the model, are listed in Table 19. The number of variables for each model was limited to 12 or less in order to have at least 10 degrees of freedom in the error term for testing. Approximately 90% of the variation from site to site was explained with a standard error of about 10 bushels per acre. Uncontrolled factors which explained the variation include past cropping (C), weed infestation (W), moisture stress (D), plant population (S), average barrenness (B), the quadratic terms of W^2, D^2, S^2 and B^2, and the interaction terms SD and CS. A similar model, but with the addition of surface and subsoil fertility factors, was selected to determine which factors influenced check plot yields most. This model and regression equation is also listed in Table 19 and revealed that climate and management factors influenced check plot yields more than indigenous fertility. A resultant R^2 of 0.910 was achieved with this equation, and the standard error was 11.1 bushels per acre.

The multiple regression models for b_N, b_N2, b_P, b_K, b_K2 and b_{NK}, listed in Table 13, as functions of the uncontrolled variables are listed in Table 20. As with the average yield regression models, independent variables were limited to 12 or less in order to permit testing with at least 10 degrees of freedom. The variability in response to nitrogen, both linear and quadratic terms, was more completely explained

Table 19. Multiple regression statistics for the regression of yield on selected uncontrolled factors which varied among sites

Dependent variable	Independent variables	Regression coefficients	t-values	R^2	Standard error
Y_A(Ave. site yield)	b_o	-408.47730	1.90+++	0.820	13.9
	R	+12.676650	0.82		
	T	+1.1762344	0.51		
	C	+0.42635398	0.61		
	W	-4.9553518	1.01+		
	D	+2.8496072	2.57*		
	S	+0.04771051	1.77++		
	B	-0.98680097	0.59		
	R^2	-2.8130559	1.01+		
	T^2	-0.05427370	0.58		
	D^2	-0.02447149	1.55++		
	S^2	-0.00000142	1.78++		
	B^2	+0.03833117	0.86		
Y_A	b_o	+227.49570	0.43	0.909	9.9
	R	+1.1002433	0.10		
	C	-8.5305556	1.66++		
	W	-12.031396	2.84*		
	D	+8.1722060	3.95**		
	S	+0.01328896	0.28		
	R^2	-1.0610848	0.55		
	D^2	-0.00872637	0.77		
	S^2	-0.00000161	3.03*		
	B^2	-0.05163963	2.16+++		
	TD	-0.00499983	0.38		
	SD	-0.00037864	3.04*		
	CS	+0.00058478	1.75++		
Y_A	b_o	+371.98584	0.82	0.888	10.4
	C	-8.7417482	1.75+++		
	W	+13.684863	0.74		
	D	+5.9362223	2.56*		
	S	-0.00181323	0.06		
	B	-1.4662177	1.30+		
	W^2	-5.0613174	1.29+		
	D^2	-0.00465833	0.50		
	S^2	-0.00000132	2.55*		

Table 19. (Continued)

Dependent variable	Independent variables	Regression coefficients	t-values	R^2	Standard error
	B^2	-0.01228993	0.29		
	SD	-0.00027281	1.94+++		
	CS	+0.00057702	1.80+++		
Y_o(check plot yield)	b_o	+957.42407	1.63++	0.910	11.1
	C^o	-16.976390	2.18*		
	W	-12.238846	2.60*		
	D	+6.2648440	3.60**		
	S	-0.03353097	1.03+		
	B_2	-3.2913389	3.60**		
	S^2	-0.00000183	2.12+++		
	SD	-0.00032565	3.06**		
	CS	+0.00111570	2.29+++		
	n	+0.04348442	1.09+		
	p	-0.21625978	0.54		
	k	+0.07324699	0.59		
	ns	+0.36006233	0.51		
	Ps	-0.68874757	0.64		
	k_s	+0.08764887	0.62		

than the others. However, all equations explained at least 60% of the variability in their respective RC's. No attempt was made to select reduced models from those listed; the variables were entered in each model on the basis of the correlation matrix and knowledge from previous investigations. Most of the individual regression coefficients were non-significant, even at the 30% probability level, but their combinations resulted in significant multiple correlation values.

Table 20. Multiple regression models for the regression of b_N, $b_N{}^2$, b_p, b_K, $b_K{}^2$ and b_{NK}, on selected uncontrolled factors which varied among sites

Dependent variable	Independent variables and level of significance of corresponding RC's	R^2	Standard error
b_N	$+R$, $-C^{+++}$, $+S^{+}$, $-R^2$, $-S^{2+}$, $+D$, $+D^2$ $-SD^{+}$, $-n$, $+n_s{}^{+++}$, $+P_s$, $+a$	0.783	.0367
$b_N{}^2$	$+R$, $+C^{++}$, $+S$, $-R^2$, $-S^2$, $+D$, $-D^{2++}$ $-SD$, $-n$, $-n_s$, P_s, $+a$	0.729	.00057
b_P	$+C$, $+S^{+}$, $-S^2$, $-D$, $+D^2$, $-n$, $-p$, $+n_s{}^{+++}$ $-P_s{}^{*}$, $-a$	0.655	.1047
b_K	$+R$, $-R^2$, $+D$, $+D^2$, $-TD^{+++}$, $+CS$, $+n^{+++}$ $-k^{*}$, $+n_s$, $+k_s{}^{+++}$, $-a$	0.612	.0462
$b_K{}^2$	$+R^{+++}$, $-R^{2+++}$, $-D$, $-D^2$, $+TD^{+}$, $-CS^{*}$ $+n^{+++}$, $-k$, $-n_s$, $+k_s$, $+a^{++}$	0.600	.0014
b_{NK}	$+C$, $-D$, $+D^2$, $-TD$, $+SD^{+}$, $-n^{+++}$, $-p^{++}$ $+k$, $+a$	0.660	.00068

Generalized yield prediction equations

A general yield equation was calculated by combining the data from all plots at all sites using a modified stepwise multiple regression technique. With 25 plots at each of 23 sites, data from a total of 575 plots were used in deriving the general yield equation.

The successive steps in arriving at a general yield equation are outlined in Table 21. Yield was regressed on each set of four types of factors, applied fertility, indigenous fertility, management and climate. The model was then built by deleting nonsignificant terms, based on 30% probability for the t-values associated with the estimated RC's and adding the next set of variables. The successive models which were examined are listed in Table 22. The variables included, statistical significance of each RC, R^2 of the model, and standard error are given.

It is well to remember as the various models are interpreted that only Equation 1 contains truly independent regression coefficients. The RC's in all other equations are intercorrelated to various degrees. These RC's indicate the effect of the particular variate after Y (yield) has been fitted to all other variates in the model. As a result, the direction of effect of any single factor must be interpreted with caution. The linear correlation between yield and each variate and between each combination of two variates is beneficial in making interpretations. The correlation matrix for this study is listed in Appendix A, Table 41.

Table 21. Steps followed in developing a generalized yield equation for all plots

Step number	Multiple regression model
1	Y = f(applied fertility)
2	Y = f(inherent fertility)
3	Y = f(management)
4	Y = f(climate)
5	Y = f(1 + 2)
6	Y = f(1 + 2 + 3)
7	Y = f(1 + 2 + 3 + 4)
8	Y = f(1 + 2 + 3 + 4 + interactions)

Inspection of Table 22 reveals that Equation 1, when derived from all plots, is completely unsatisfactory in fitting the observed yield as indicated by the R^2 of 0.04 and standard error of 24.6 bu/A. Obviously, factors other than applied fertility were paramount in determining yields. The addition of stand level, Equation 1a, does not greatly improve the relationship. However, the addition of the barrenness covariate does make a sizeable contribution towards explaining yield variability.

Indigenous soil fertility, Model 2, does not explain yield variability to any great extent by itself but both

Table 22. Stepwise multivariate regression equations used to evaluate the grain yield of corn using data from 575 plots at 23 sites

Equation number	Independent variables and level of significance of corresponding RC's	R^2	Standard error
1	$+N^{***}, -N^2, +P^{++}, -P^2, -K^+, +K^2$ $+NP, +NK, +PK$	.039	24.6
1a	$+N^{***}, -N^2, +P^+, -P^2, -K, +K^2$ $+NP, +NK, +PK, -S^*$	.051	24.5
1b	$+N^{**}, -N^{2+}, +P^{++}, -P^{2+}, +K^2$ $-NP, +NK, +PK, +S^{***}, -B^{***}$	.327	20.7
2	$+n^{***}, -p^{++}, -k^{+++}, +a, -n_s^{***}$ $-Ps^{++}, +k_s^{***}, -a_s$	.155	23.1
3	$+R^{+++}, +T^{**}, +W^{+++}, +S^*, +C^+$ $-R^{2+++}, -T^{2+}, -C^2, -S^{2***}$	.192	22.6
4	$+D^{***}, -D^{2+}$	.465	18.3
5	$+N^{***}, -N^2, +P^{++}, -p^2, -K^+, +K^2$ $+NP, +NK, +PK, +n^{***}, -p^{++}, -k^{+++}$ $-n_s^{***}, -p_s^+, +k_s^{***}, +a, -a_s$	.195	22.7
6	$+N^{***}, -N^{2+}, +P^*, -P^{2+++}, +K, +K^2$ $-NP, -NK, -PK, -B^{***}, +n^{***}, -p^+$ $-k^*, -n_s^{***}, -P_s^*, +k_s^{***}, -a^{**}, +a_s^{***}$	.670	14.6
7	$+N^{***}, -N^{2+}, +P^*, -P^{2+++}, -K, +K^2$ $-B^{***}, +n^{**}, -p, -k^*, -n_s^{***}, -P_s$ $+k_s^{***}, -a^{***}, +a_s^{***}, +R, +T^{***}$ $+C^{**}, +R^2m +S^{***}, +S^2, +D^{**}, -D^2, -H^{***}$	.764	12.4

Table 2. (Continued)

Equation number	Independent variables and level of significance of corresponding RC's	R^2	Standard error
8	$-N, -N^{2+}, +P^{+++}, -P^{2*}, +K, -B^{***}$ $+B^{2+}, +n^{***}, -p^{*}, -k^{**}, -n_s{}^{***}, +p_s$ $+k_s{}^{***}, -a^{***}, +a_s{}^{***}, +R, +T^{**}, +C^{*}$ $+S, +S^{2++}, +D^{*}, -H^{***}, +RN^{++}, +aN, -nN$ $+DN^{**}, -RN^{2+++}, n_sN^2, +CN^{2++}, -DN^{2+++}$ $-p_sP, -pP, -nP^{++}, +DP^{+}, +pP^{2+++}, -RK^{+++}$ $+kK, +DS^{*}, -TD^{***}, +CS$	.798	11.6
8a	$-N, -N^{2+++}, +P, -p^{2*}, -B^{***}, +B^{2***}$ $+n^{***}, -p^{*}, -k^{**}, -n_s{}^{***}, +k_s{}^{***}$ $-a^{***}, +a_s{}^{***}, +R^{**}, +C^{+++}, +S^{+++}$ $+D^{+}, -H^{***}, RN^{+}, -nN, +DN^{**}, -RN^{2++}$ $+n_sN^{2+}, +CN^{2++}, -pP^{+}, +DP^{+}, +pP^{2+++}$ $+DS^{++}$	.777	11.8
8b	$-N, -N^{2+}, +P^{++}, -P^{2*}, -K, -B^{***}$ $+n^{***}, -p^{**}, -k^{**}, -n_s{}^{***}, +k_s{}^{***}$ $+a_s{}^{**}, +R, +T^{*}, +S, +C^{***}, +D^{*}, -H^{***}$ $+RN^{++}, +DN^{***}, +RN^2, +n_sN^2, +CN^{2++}$ $-DN^{2+++}, -pP, -nP^{++}, +DP^{+}, pP^{2+++}$ $+DS^{**}, -TD^{***}$	.791	11.7

surface and subsoil N, P and K appear significant. Models 1 and 2, applied and indigenous fertility, appear to be nearly additive as indicated by Equation 5. That is, applied fertility did not explain the same variability as the indigenous fertility variables. It is apparent that applied N and P both had significant positive effects on yield, but that the effect of K was slightly negative. The fertilizer interaction terms, NP, NK and PK were not significant. Interpretation of the individual effects of soil test levels is difficult because of the high degree of intercorrelation among them.

The model which included management factors and their quadratic terms, Equation 3, explained about 20% of the variability in yield. Higher yields were associated with more continuous corn, later planting, more weed infestation, higher plant population and higher soil yielding potential, but at decreasing rates as indicated by the negative quadratic terms. The directions of the influence of planting date and weed infestation are opposite from that indicated in most previous studies for reasons discussed earlier pertaining to response to applied N.

The factor, or group of factors, which explained the largest portion of yield variability, by itself, was climate. A simple quadratic equation containing only the Laing-Shaw relative photosynthesis index and its squared term resulted in an R^2 value of 0.465. The effect was nearly linear, but the quadratic term was significant at the 30% level.

Model 6, which is the summation of models 1b, 2 and 3, resulted in an R^2 of 0.67. This model contained all factors except climate. The three models, 1b, 2 and 3, were nearly additive, indicating that they were probably not measuring the same sources of variability. The further addition of model 6, climate, and a dummy soil moisture variable for one site (No. 40), resulted in an increase in the R^2 of only 0.094.

Interaction terms were selected for a final yield equation on the basis of correlations, listed in Tables 17 and 18 and on the regression equations listed in Table 19. Table 19 reveals that the factors responsible for most of the variation in yield among sites could be explained by the management factors in model 3, the stress index, and interactions between stand and stress, between stand and soil yield potential, and between planting date and stress. In a previous section of this discussion, entitled "Variation in response among sites", the factors influencing the variability in the fertilizer coefficients among sites were determined. The suggested interactions were entered into Model 8. The resulting equation, including the values of regression coefficients, is listed in Table 23. This

Table 23. Regression equation resulting from Model 8 and containing significant main effects and suggested interaction terms

Regression variate	Regression coefficient	t-value
b_o	-27.025	
N	-0.05079	0.46
N^2	-0.00213	1.17+
P	0.23923	1.65+++
P^2	-0.00529	2.37*
K	0.00780	0.19
n	0.32572	6.80***
p	-0.14808	2.47*
k	-0.02571	2.73**
a	-6.3277	3.61***
n_s	-1.5215	7.99***
P_s	0.11907	0.49
k_s	0.64679	8.08***
a_s	10.785	4.28***
R	0.71459	0.85
T	1.3369	2.89**
C	0.39786	2.01*
S	0.33365	0.60
B	-1.4413	8.11***
S^2	0.01865	1.56++
H	-13.531	10.9***
D	0.84761	2.71**
RN	0.00805	1.30++
aN	0.00766	0.49
nN	-0.00041	0.71

Table 23. (Continued)

Regression variate	Regression coefficient	t-value
DN	0.00150	3.12**
RN^2	-0.00017	1.68+++
n_sN^2	0.00001	0.66
CN^2	0.00003	1.49++
DN^2	-0.00002	1.93+++
p_sP	-0.00197	0.34
pP	-0.00054	0.30
nP	-0.00306	1.64++
DP	0.00174	1.12+
pP^2	0.00011	1.69+++
RK	-0.01913	1.86+++
kK	0.00011	0.79
DS	0.04177	2.49*
B^2	0.00440	1.14+
TD	-0.05288	4.97***
CS	-0.00055	0.21

R^2 = 0.798 standard error = 11.6 bu/A

equation contained 40 variables and attained an R^2 value of 0.798. The equation resulted in a standard deviation of 11.6 bu/A.

Despite the statistical nonsignificance of some of the regression coefficients in Equation 8, based on a probability level of approximately 30% (or t $\geq$1.0), these estimates are believed to be the best available. Thus, this equation will be used to further evaluate the effect of the many uncontrolled variables on N, P and K response.

The linear fertilizer N term was slightly negative and nonsignificant, in contrast to all previous models which were evaluated. This indicates that response to nitrogen was almost entirely a function of the uncontrolled factors in this experiment. If the fertilizer terms were decoded, the resultant RC's would indicate a slight positive response to N but at a significantly decreasing rate. The response to fertilizer P was not as greatly influenced by uncontrolled factors as response to N was. Response to P was positive but at a decreasing rate. Fertilizer response to potassium appeared negligible without consideration of the uncontrolled factors.

The direction and degree of the effect of uncontrolled variables on response to N, P and K can be assessed from the partial derivatives of the yield equation with respect to each of the fertilizer terms. These resultant equations indicate the rate of change in response to N, P or K as the uncontrolled factors are varied.

The rate of change equation for N, using Equation 8, is, as follows:

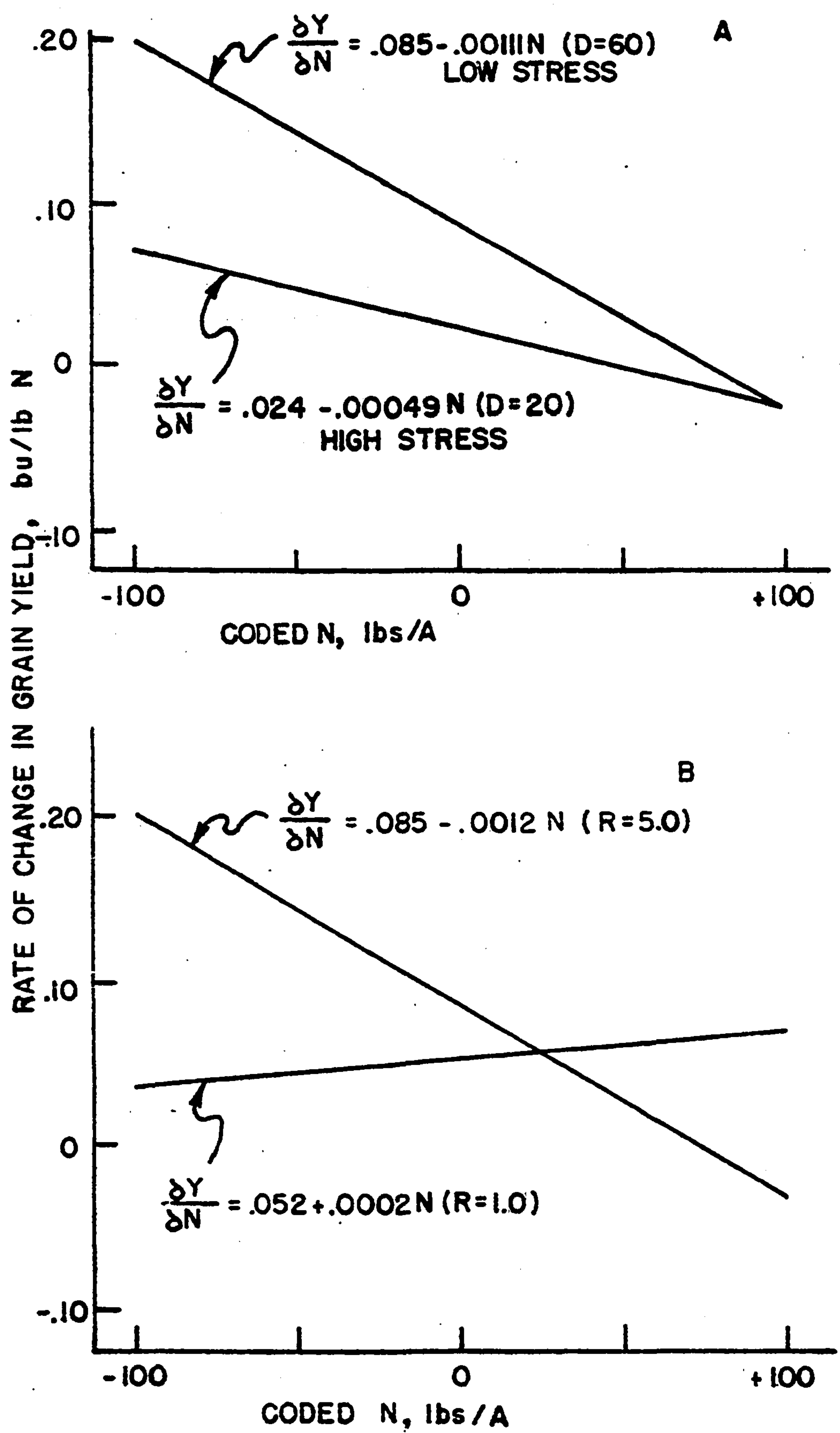
$$\frac{\partial Y}{\partial N} = -0.05079 - 0.00426N + 0.00805R + 0.00766a - \quad (4)$$
$$0.0041n + 0.00150D - 0.0034RN + 0.00002n_sN +$$

$0.00006CN - 0.00004DN$ (4 Cont'd)

The intercept value, -0.05079, indicates the initial response to the first infinitesimal increment. This intercept is influenced by the level of R, a, n and D, factors which interacted with the linear N term. The slope of the rate of change equation is altered by terms which still include N, namely R, n_s, C and D.

The specific effects of the uncontrolled factors can best be determined from graphic illustrations. Figure 4 illustrates the rate of change in grain yield per pound of applied N as influenced by climatic conditions and by past cropping. In order to evaluate the effect of any given uncontrolled factor, all other factors must be held constant. Thus, the effect of soil moisture stress was evaluated at the average experimental values of the other variables in the rate of change equation. These were a (soil pH) = 6.5, n (soil N) = 60 pp2m, R (past cropping) = 2.5, n_s (subsoil N) = 20 pp2m, and C (soil yield potential) = 100 bu/A. The value of D = 40 (the average was 35) was used as a constant in evaluating the effects of other uncontrolled variables. Initial response to N under conditions of little or no moisture stress (D = 63 is maximum value, D = 0 is minimum) was much greater than initial response under conditions of considerable stress. The rate, at which yield is increased, decreases at a faster rate under low stress, so at the

Figure 4. Rate of change equation of grain yield with respect to fertilizer N at two levels of moisture stress and two levels of past cropping


A
$\frac{\delta Y}{\delta N}$ = .085-.00111N (D=60)
LOW STRESS
$\frac{\delta Y}{\delta N}$ = .024 -.00049 N (D=20)
HIGH STRESS
.20
.10
0
-.10
-100
0
+100
CODED N, lbs/A
RATE OF CHANGE IN GRAIN YIELD, bu/lb N
B
$\frac{\delta Y}{\delta N}$ = .085 - .0012 N (R=5.0)
$\frac{\delta Y}{\delta N}$ = .052+.0002N (R=1.0)
.20
.10
0
-.10
-100
0
+100
CODED N, lbs/A

highest rate of applied N, 200 pounds per acre (+100 in coded value), the response is the same as under high stress. This is a slightly negative response. The point at which the rate of change lines cross zero indicate the N fertilizer rate at which maximum yield is predicted. For low stress, this was approximately 175 lbs N/A. That is, yields increased up to these levels of N and began decreasing from this maximum at rates of N higher than these.

The influence of past cropping on response to N is illustrated in Figure 4B. The values R = 1.0 and R = 5.0 represent first year and fifth year corn following meadow, respectively. As would be expected, an increase in N on first year corn does not affect yield much at any rate of N. But, the effect is positive and increases in effect as N rates are increased. In contrast fifth year, "continuous", corn responded greatly to initial levels of N, with this response becoming less positive as N rates increase. The maximum yield was predicted at 175 lbs N/A, above which yields would be predicted to decrease.

Other factors which had an influence on response to N, as indicated by the rate of change equation, were soil pH, soil N, subsoil N and soil yielding potential. The response was greater at higher soil pH but this effect was the same for all levels of N. The response to N was greater as soil

N decreased, but again, the effect was indicated to be the same for all rates of N.

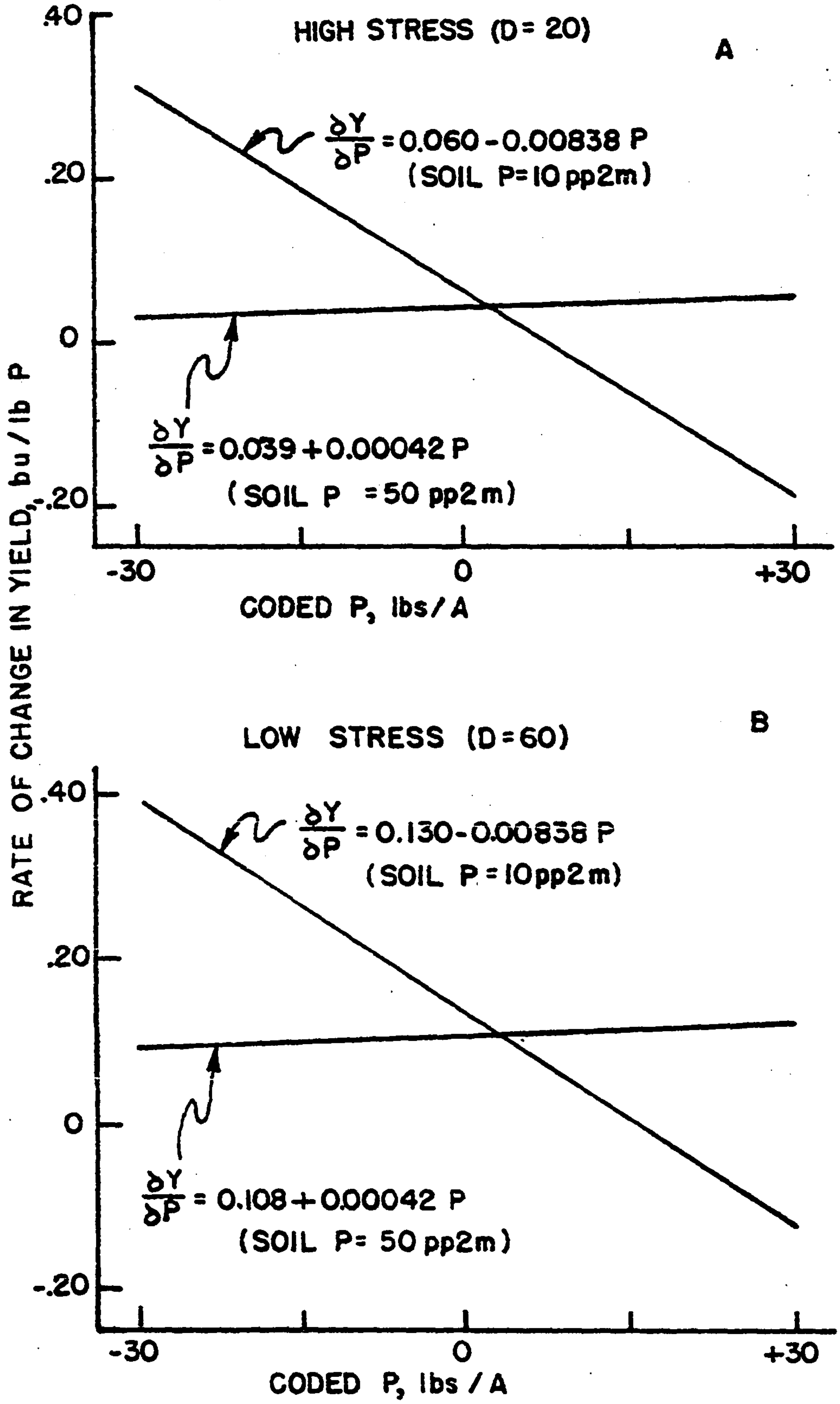
The rate of change equation for fertilizer P is, as follows:

$$\frac{\partial Y}{\partial P} = 0.23923 - 0.01058P - 0.00197_{p_s} - 0.00054p - 0.00306n + 0.00174D + 0.00022pP \qquad (5)$$

Figure 5 illustrates the change in P response as soil P is varied under two extreme conditions of moisture stress. Soil N was held constant at 60 pp2m and subsoil P, p_s, was held constant at 12.5 pp2m, the average experimental values. Figure 5A reveals that response to P is negligible at a soil test level of 50 pp2m of "available" P. But, at a "very low" soil test level of 10 pp2m, the response was highly positive at initial rates, but became less positive as P rates increased. The maximum yield was predicted at approximately 35-40 lbs P/A (5-10 coded), and at the highest rate of applied P, 60 lbs/A (30 coded), a sizeable negative response could be expected from the next infinitesimal increment.

The slope of the lines in Figure 5B are the same as those in Figure 5A. But, the rate of change for each increment of applied P is slightly higher under more favorable moisture conditions (D = 60) than under conditions of greater stress. The maximum yield for conditions of soil P = 10 ppm

Figure 5. Rate of change equation of grain yield with respect to fertilizer P at two levels of soil P, each at two levels of moisture stress


HIGH STRESS (D= 20)
A
$\frac{\partial Y}{\partial P}$ = 0.060 - 0.00838 P
(SOIL P=10 pp2m)
$\frac{\partial Y}{\partial P}$ = 0.039 + 0.00042 P
(SOIL P = 50 pp2m)
.40
.20
0
-.20
-30
0
+30
CODED P, lbs/A
RATE OF CHANGE IN YIELD, bu/lb P
LOW STRESS (D=60)
B
$\frac{\partial Y}{\partial P}$ = 0.130 - 0.00838 P
(SOIL P = 10 pp2m)
$\frac{\partial Y}{\partial P}$ = 0.108 + 0.00042 P
(SOIL P= 50 pp2m)
.40
.20
0
-.20
-30
0
+30
CODED P, lbs / A

and D = 60 was predicted for applied P rate of approximately 45 lbs P/A (15 coded) slightly higher than under stress conditions of D = 20.

The rate of change equation for yield with respect to applied potassium is, as follows:

$$\frac{\partial Y}{\partial K} = 0.00780 - 0.01913R + 0.00011K \qquad (6)$$

The absence of K terms in the rate of change equation indicate that the slope of the equation is zero and the effects of past cropping (R) and soil K (k) are constant at all levels of applied K. The rate of change equation indicates that as distance from meadow is increased, the response to applied K becomes less positive (or more negative). That is, continuous corn has the effect of supplying potassium to the plant. The soil K term in the rate of change equation was not significant and was in the opposite direction from what would be expected. A slightly greater response to potassium is indicated as soil K increases. However, it should be kept in mind that the range of soil test K levels measured in this experiment was 170-420 pp2m, all in the "medium" and "high" range.

In addition to rate of change equations for each of the applied fertilizer nutrients, similar equations can be determined for some of the uncontrolled factors, which influenced grain yield differently at varying levels of other factors. The rate of change equation for plant population, or stand level, is, as follows:

$$\frac{\partial Y}{\partial S} = 0.33365 + 0.0373S + 0.04177D - 0.00055C \qquad (7)$$

The effect of stand level on yield was influenced by moisture stress, soil yield potential (not significantly) and changed with stand level itself. Figure 6 illustrates the influence of moisture stress on response to stand. Under both conditions, stand levels increase yield at an increasing rate but, at any given population, the response under more favorable conditions is constantly 1.5 bu/1000 plants greater. The actual response to increasing stand levels at any given stress level is quite small in proportion to the effect of stress but is statistically significant.

The effect of soil moisture stress on grain yield, as measured by the Laing-Shaw relative photosynthesis index, is influenced by the level of applied N, applied P, plant population and planting date, as indicated in the following rate of change equation:

$$\frac{\partial Y}{\partial D} = 0.84761 + 0.0015N - 0.00004N^2 + 0.00174P + 0.04177S - 0.05288T \qquad (8)$$

The absence of D in this equation indicates that the effects of N, P, S and T on yield response to D are not dependent on the level of D. For example, an increase in D from 59 to 60

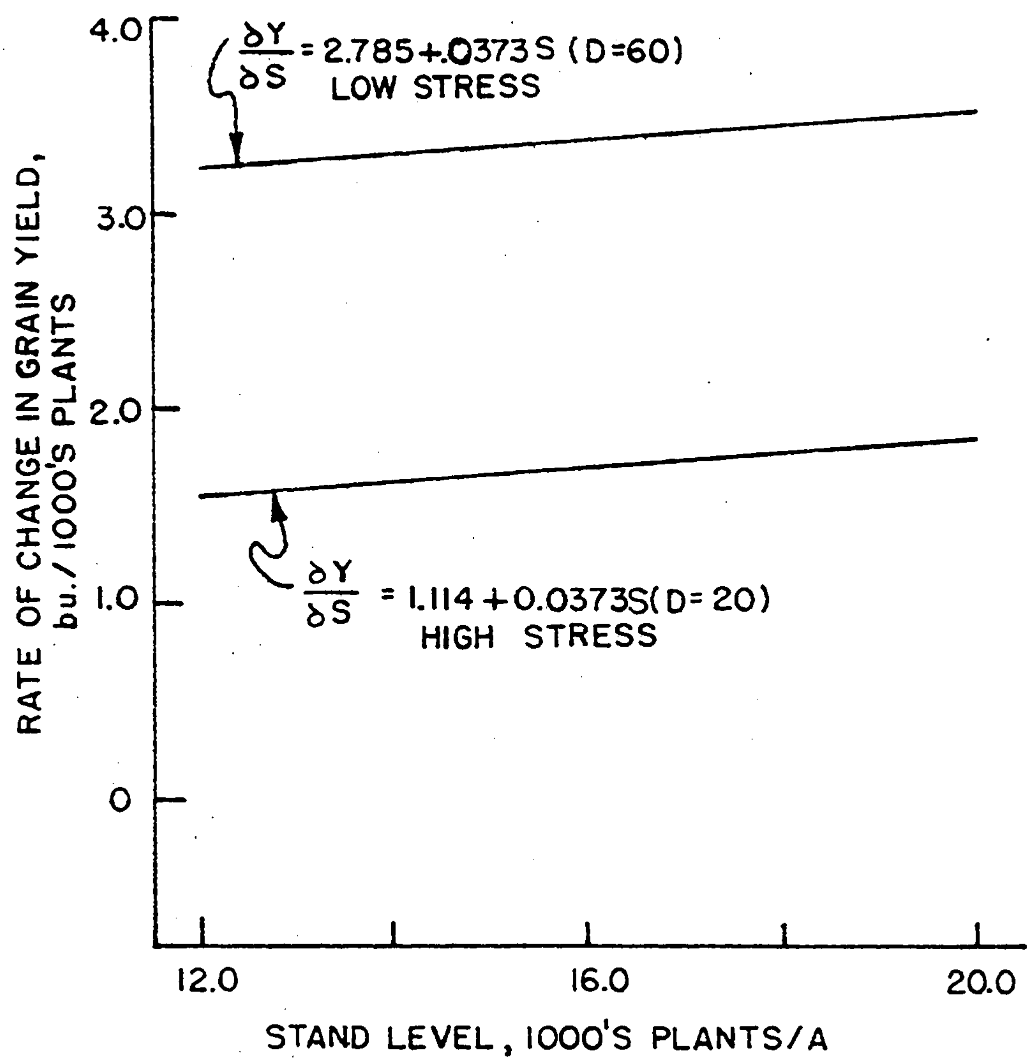


Figure 6. Rate of change equation of grain yield with respect to plant population at two levels of moisture stress

will result in the same yield increase as an increase in D from 20 to 21 for any given level of N, P, S and T. With this in mind, Figures 7 and 8 illustrate the influence of increasing levels of N, P, S and T on yield response to soil moisture.

Figures 7A and B illustrate the same effects as in Figures 4A and 5. That is, yield response to soil moisture is greater at increasingly higher rates of N and P. However, maximum increase occurred at N rates of approximately 125 lbs/A, above which the response to soil moisture became less positive. The nearly flat line in Figure 7B indicates that the soil moisture-applied P interaction, while sufficiently consistent to be significant at the 30% level of probability, was quite small in value. That is, soil moisture efficiency was not greatly increased with higher rates of P.

Figure 8B indicates the positive interaction between soil moisture and plant population. Response to moisture increased as stand was increased from 12,000 to 20,000 plants per acre.

The effect of planting time on response to moisture stress was highly significant. The later planting dates of 1967 were associated with higher yields than the earlier planting dates of 1968. But the response to additional moisture was much greater in 1968, when planting dates were earlier. It is difficult to separate cause and effect in

Figure 7. Rate of change equation of grain yield with respect to moisture stress as influenced by levels of fertilizer N and P

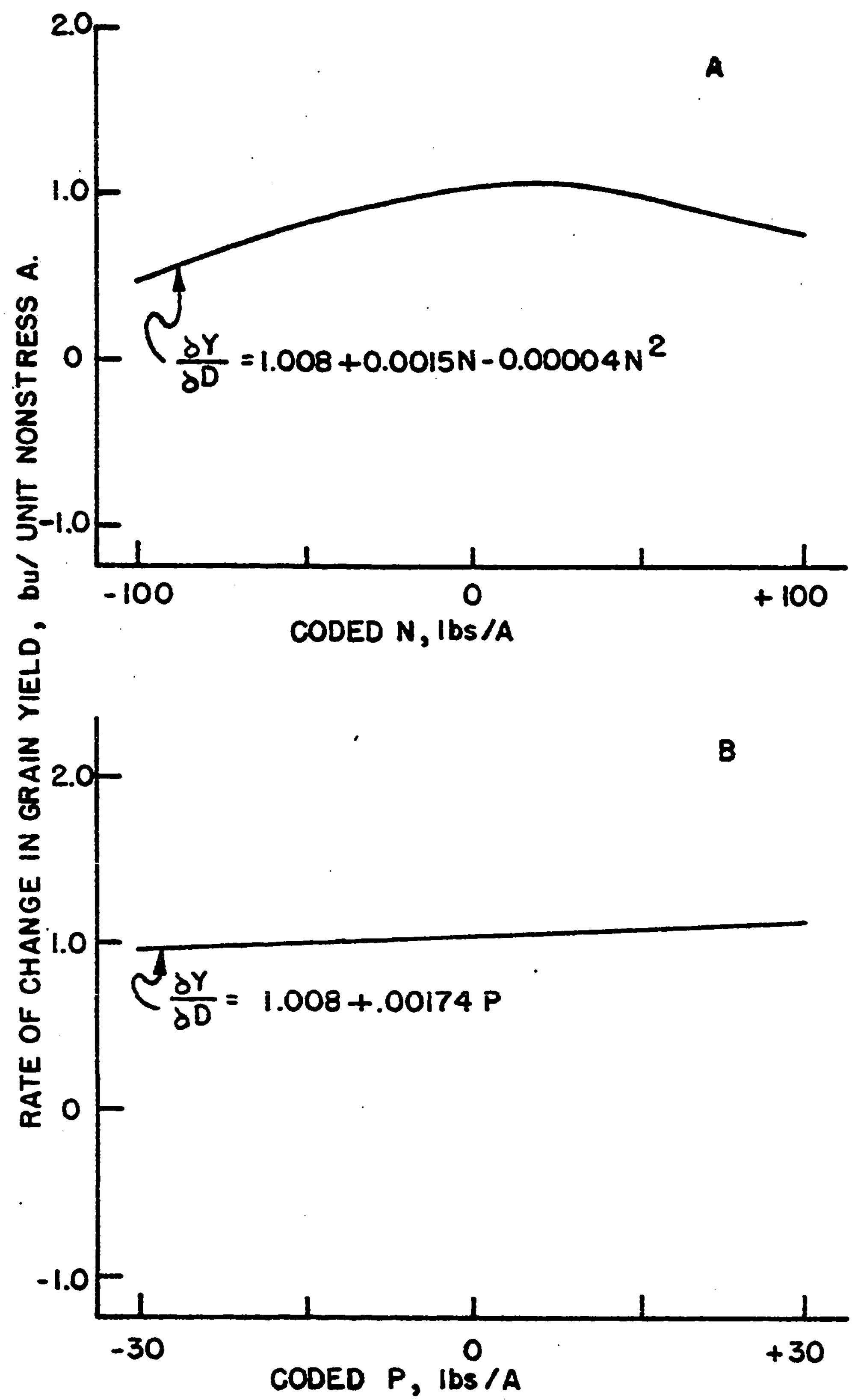
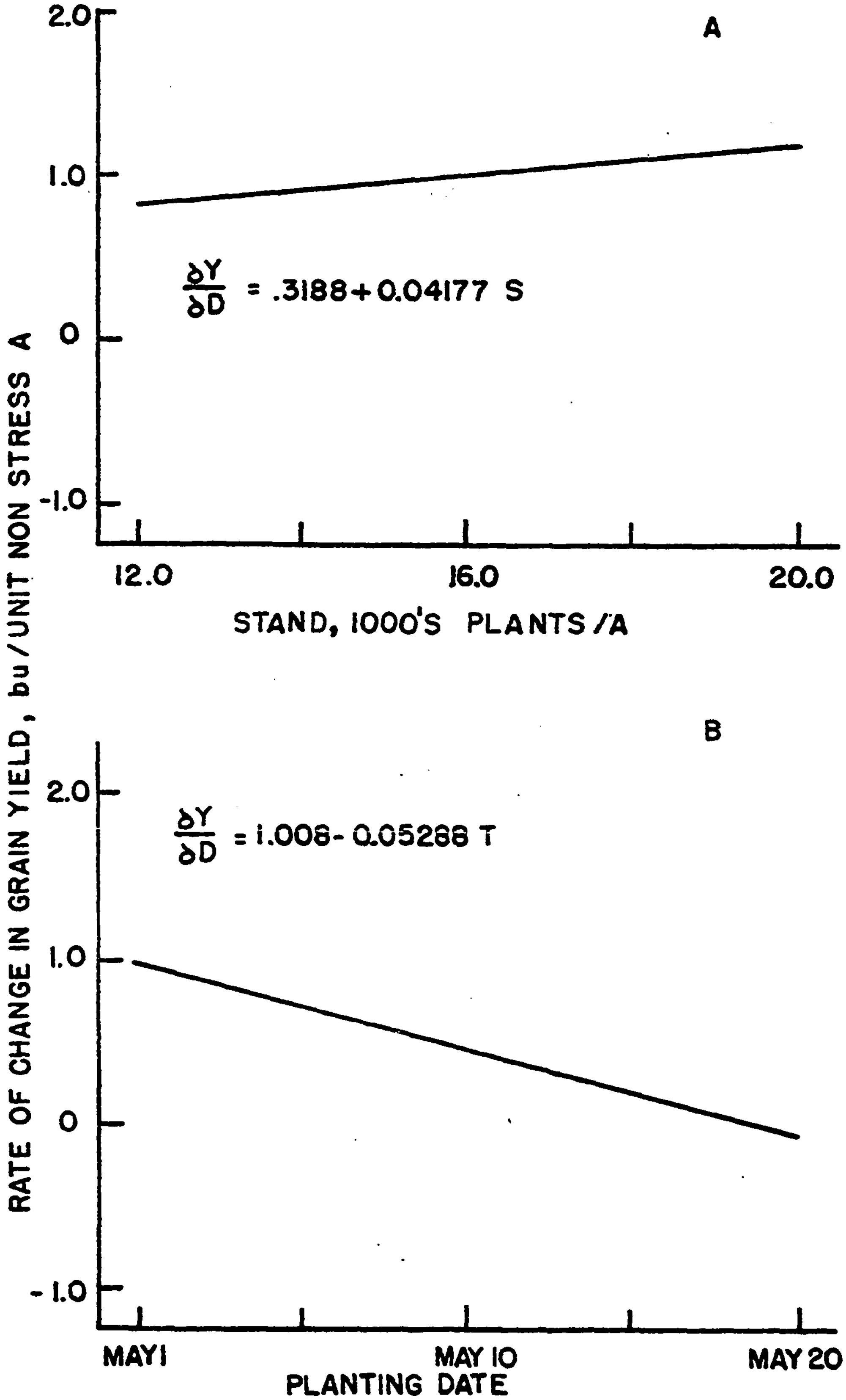

A
B
RATE OF CHANGE IN GRAIN YIELD, bu/ UNIT NONSTRESS A.
2.0
1.0
0
-1.0
-100
0
+100
CODED N, lbs/A
$\frac{\delta Y}{\delta D} = 1.008 + 0.0015N - 0.00004N^2$
-30
0
+30
CODED P, lbs/A
$\frac{\delta Y}{\delta D} = 1.008 + .00174P$

Figure 8. Rate of change equation of grain yield with respect to moisture stress as influenced by plant population and planting date



A
2.0
1.0
0
-1.0
$\frac{\partial Y}{\partial D}$ = .3188+0.04177 S
12.0
16.0
20.0
STAND, 1000'S PLANTS/A
RATE OF CHANGE IN GRAIN YIELD, bu/UNIT NON STRESS A
B
2.0
1.0
0
-1.0
$\frac{\partial Y}{\partial D}$ = 1.008- 0.05288 T
MAY 1
MAY 10
MAY 20
PLANTING DATE

Table 24. Final yield equation, regression Equation 8b, relating grain yield to controlled and uncontrolled factors and significant interactions among the various factors

Regression variate	Regression coefficient	t-value
b_o	-48.361	
N	-0.02486	0.49
N^2	-0.00234	1.28+
P	0.22696	1.63++
P^2	-0.00545	2.43*
K	-0.01116	0.95
n	0.32735	6.95***
p	-0.13811	2.65**
k	-0.02635	2.83**
n_s	-1.6498	8.75***
k_s	0.65079	8.48***
a_s	6.0220	2.84**
R	0.63174	0.80
T	1.1371	2.46*
C	0.58781	3.42***
S	0.27690	0.52
B	-1.2193	14.3***
H	-13.784	11.4***
D	0.68373	2.37*
RN	0.00829	1.34++
DN	0.00166	3.48***
RN^2	-0.00016	1.62++
n_sN^2	0.00002	0.71
CN^2	0.00003	1.58++

Table 24. (Continued)

Regression variate	Regression coefficient	t-value
DN^2	-0.00002	1.88+++
pP	-0.00109	0.88
nP	-0.00294	1.56++
DP	0.00169	1.08+
pP^2	0.00011	1.75+++
DS	0.04137	3.24**
TD	-0.05115	4.85***

R^2 = 0.791 standard error = 11.7 bu/A

in this experiment, but Figure 8B does describe the relationship which existed.

As stated earlier, Equation 8 contained 41 variable and resulted in an R^2- value of 0.798. For prediction purposes, Equation 8b appears equally satisfactory. It contained only 30 variables and attained and R^2 - value of 0.791. This equation is listed in full in Table 24.

PART II. LEAF ANALYSIS

REVIEW OF LITERATURE

The nutrient content of leaves of corn and other crops has been studied for more than twenty years. The primary objectives of plant analysis include the establishment of critical nutrient concentrations above which no further yield increase is expected and establishment of the nutrient concentration associated with the most profitable yield. If these objectives are achieved, plant analysis can be useful in determining fertilizer requirements. However, the above mentioned concentrations are difficult to define because they have been found not to be points on a curve, but levels which vary with the concentrations of the other nutrients, as well as with variations in climate, population, variety and other factors (Hanway and Dumenil, 1955).

Tyner and Webb (1946) conducted some of the first extensive investigations on corn leaf analysis. Their studies, and most since then, have been concentrated on N, P and K. However, since 1960, the role and importance of micronutrients and their balance has been emphasized through plant analysis (Overdahl, 1965).

Hanway (1962) investigated the change in concentration of N, P and K in each of the major corn plant parts throughout the season. He found the various parts differed greatly in their concentrations and uptake patterns. Leaves and leaf sheaths showed greatest differences in percent total N, P and K under conditions of nutrient deficiencies. These differences were greatest near silking. These are two of the reasons that the leaf opposite and below the main ear shoot, sampled at early silking, has become a standard for assessing the nutrient status of a corn plant.

Hanway (1962) and Voss (1966) observed that differences in soil fertility influenced the amounts of N, P and K taken up by corn plants, but the uptake pattern was not changed, nor was the distribution within the plant.

Interactions among the concentrations of the various nutrients in the plant have been reported by many investigators, but the magnitude and directions of these interactions have not been entirely consistent. This indicates further interaction with other variables, the most commonly reported being climatic factors.

Tyner and Webb (1946) found that an increase in the amount of applied N depressed percent K in the leaf. Applications of K had only a slight negative effect on percent N. Applied P had no effect on the N or K content of corn leaves in their experiments, nor did applied N or K appear to affect the P content. However, Dumenil (1958), Voss (1962) and others reported results almost opposite of these.

Hanway (1962) found that severe nitrogen deficiency resulted in low P and high K in the leaves. This illustrates the difficulty of interpreting analyses when more than one nutrient appears to be deficient. Murdock et al. (1962) further illustrated the importance of nutrient balance. They found that when only one nutrient was applied, disregarding the possible need for others, detrimental effects occurred. When N and P were both applied in their experiment, maturity was hastened, but N, P or K alone delayed maturity. Similar relationships were observed with yield and lodging. They further reported increased N and P uptake from N, P or K fertilizer and increased K uptake from N or K fertilizer.

Spies (1956) reported that attempts to predict yields by means of plant analysis have been generally unsuccessful. However, he was able to obtain a multiple correlation square value (R^2) of 0.81 with an equation containing only linear terms for percent leaf N and P. He found that leaf N and P, and occasionally K, were influenced positively by fertilizer N. Applications of P fertilizer decreased leaf K and increased leaf P only where soil P was sufficiently low to also effect a yield increase. Applications of K fertilizer decreased leaf N at low rates of N fertilizer application and increased leaf K; however, these effects were small. Spies obtained a high correlation between leaf N content and yield increase and between leaf N and leaf P. However, the correlation between leaf N and leaf K or leaf P and leaf K were low. His studies were conducted on southwestern Iowa bottomland soils well supplied with K and moderately well supplied with P.

Barber et al. (1961), Hanway et al. (1961) and Hanway et al. (1962), studying potassium in relation to corn, millet and alfalfa found that correlations between %K in the plant, total K uptake and percent recovery of added K were not high, indicating that environmental conditions have a marked effect on K uptake. They did observe that increases in corn grain yields from K fertilization were more highly correlated with percent K in leaves at silking that with exchangeable K contents of the soils.

Thus, the literature reveals that plant analysis has potential in attempting to evaluate fertilizer needs, but that the basic relationships between plant nutrient content and the pertinent soil, plant, climate and management factors must be developed further before predictions with any certainly can be formulated.

RESULTS AND DISCUSSION

The nutrient content of corn leaves at silking time was studied with two objectives in mind. The first was to determine which factors were responsible for a given nutrient content. The second objective was to determine the magnitude of the correlation between grain yield and leaf content.

Relationship Between Leaf Content and Experimental Variables

An approach, to determine which factors influence leaf content, similar to that of determining which factors influenced grain yield was utilized. This procedure was to obtain regression coefficients (RC) for Equation 1, given on page 72 , where Y is grain yield, leaf N, leaf P or leaf K content. Secondly, an F-ratio between "Among Sites" and "Within Sites" Error Mean Squares was used to determine which RC's varied from site to site and thus which RC's were influenced by factors other than applied variables. The values for the respective RC's for each dependent variable (Y) from each site were considered as dependent variables in regression models in which factors that varied among sites were the independent variables. Significant terms from these equations suggested interactions between the particular fertilizer RC's and site variables. These interaction terms were then included in the development of a generalized equation.

Characterization of individual sites

Table 25 lists the RC's obtained from Equation 1 at each of the 23 sites, where Y is the percent total N in the leaf. Applied nitrogen clearly increased the leaf N concentration, the linear term being significant at 22 of the 23 sites. Twenty of these 22 were significant at the 5% level of probability. The rate of increase in N concentration decreased at higher rates of applied N as indicated by negative RC's for the quadratic term at 21 of the sites, 16 of which were significant at the 30% level. The influence of applied P on leaf N was negligible at most sites. However, at six sites a significant and negative decrease in leaf N resulted from applied P in contrast to only one site at which the effect was significant and positive. The quadratic fertilizer P term was equally nonsignificant, with five significant and positive RC's and two significant and negative RC's. The influence of applied K was not large, nor clearly defined. At eight sites the effect was significant and negative, and at four sites the effect was significant and positive. Most of the nonsignificant RC's were negative, however, which might indicate a trend. The quadratic terms were generally nonsignificant. Few interactions between applied fertilizer

Table 25. Regression coefficients and R^2-values obtained from fitting a second degree polynomial with interactions to leaf N concentrations from each site

Regression coefficient[a]	Site number 02	03	04	05
b_o	2.5602	2.4326	2.6965	2.4915
$b_1(N)$	0.0959*	0.0784++	0.0313	0.2697***
$b_2(N^2)$	-0.0001	0.0002	-0.0017*	-0.0004
$b_3(P)$	0.1110	-0.0787	-0.1532	0.0769
$b_4(P^2)$	-0.0024	0.0053	0.0031	0.0048
$b_5(K)$	-0.0127	-0.0244	-0.1766	-0.1076++
$b_6(K^2)$	-0.0004	0.0010	-0.0019	0.0026+
$b_7(NP)$	0.0018+	0.0006	-0.0027++	-0.0022+
$b_8(NK)$	0.0005	0.0005	-0.0011+	-0.0006
$b_9(PK)$	0.0000	0.0080+++	0.0010	0.0044+
R^2	0.412	0.315	0.573	0.713
	06	09	11	12
b_o	2.6859	2.6812	2.7642	2.5065
b_1	0.0782**	0.1362**	0.0682*	0.0435+
b_2	-0.0008+++	-0.0012+++	-0.0006++	-0.0003
b_3	0.0576	-0.0948	0.0075	0.1299
b_4	-0.0017	0.0072+	0.0043	0.0140+++
b_5	-0.0839+++	-0.0123	-0.0893+++	-0.0257
b_6	0.0005	-0.0013	0.0009	0.0041*
b_7	0.0001	-0.0016	-0.0010	-0.0005
b_8	0.0007+	0.0013	-0.0009++	0.0003
b_9	0.0003	-0.0018	-0.0013	0.0050++
R^2	0.562	0.592	0.536	0.492

[a]Listed RC's have been multiplied by 100 to conserve space, with the exception of b_o, the regression constant.

Table 25. (Continued)

Regression coefficient	Site number 17	20	21	22
b_o	2.7447	2.8003	2.7842	2.6900
b_1	0.0897**	0.1284***	0.1335***	0.1269***
b_2	-0.0006++	-0.0012*	-0.0003	-0.0004
b_3	-0.0817	0.0402	-0.1614++	-0.0921
b_4	0.0087+++	-0.0004	-0.0031	-0.0022
b_5	-0.0389	-0.0955*	0.0548+	0.0761++
b_6	-0.0004	-0.0007	-0.0020++	0.0008
b_7	0.0022+++	0.0010	0.0013+	-0.0006
b_8	-0.0010++	0.0003	-0.0001	-0.0001
b_9	-0.0037+++	0.0028++	-0.0048*	0.0015
R^2	0.650	0.713	0.705	0.585
	23	26	27	29
b_o	2.5302	2.9190	2.9314	3.1568
b_1	0.1111***	0.0829*	0.1878***	0.1414***
b_2	-0.0007++	-0.0008++	-0.0013**	-0.0011+++
b_3	0.0750	-0.0690	0.0384	0.0905
b_4	-0.0027	0.0026	0.0019	0.0040
b_5	0.0186	0.0009	0.1199*	-0.0553
b_6	0.0003	-0.0013	0.0002	-0.0003
b_7	0.0022+++	0.0004	0.0037**	0.0011
b_8	-0.0014*	-0.0002	-0.0005	-0.0012++
b_9	0.0017	0.0003	-0.0002	0.0044+++
R^2	0.645	0.364	0.831	0.625

Table 25. (Continued)

Regression coefficient	Site number 31	32	33	36
b_0	2.8774	3.0582	2.8304	3.1843
b_1	0.2709***	0.1795***	0.1795***	0.1585***
b_2	0.0001	-0.0017**	-0.0013*	-0.0011+++
b_3	-0.2451+++	-0.2463*	-0.2056+++	-0.1850++
b_4	0.0088+	0.0060+	0.0041	-0.0073+
b_5	-0.1129+++	0.0102	-0.0832++	-0.0436
b_6	-0.0012	-0.0025++	0.0018+	0.0026++
b_7	-0.0016	0.0024++	0.0002	-0.0003
b_8	0.0002	0.0001	0.0002	0.0003
b_9	0.0021	-0.0023	0.0046+	-0.0024
R^2	0.771	0.765	0.854	0.653
	38	39	40	All sites combined
b_0	3.0039	2.8190	2.7761	2.7756
b_1	0.2662***	0.2378***	0.3503***	0.1549***
b_2	-0.0015**	-0.0008	-0.0033**	-0.0009***
b_3	-0.0980	0.2696+++	-0.1371	-0.0404
b_4	-0.0025	-0.0082	-0.0065	0.0024
b_5	-0.0058	-0.1448+++	0.1562++	-0.0289+
b_6	-0.0006	-0.0004	-0.0013	0.0002
b_7	0.0004	-0.0019	-0.0004	0.0002
b_8	0.0011++	0.0012+	-0.0027*	-0.0002
b_9	-0.0058*	0.0065+++	0.0024	0.0010
R^2	0.862	0.726	0.791	0.209

terms were indicated. The NP interaction was significant and positive at six sites and significant and negative at two sites. The NK interaction term was significant and negative at six sites and significant and positive at four sites. The PK interaction term was significant and positive at seven sites and significant and negative at three sites. A positive interaction term, eg. NP, indicates that leaf N concentration was increased by either of the fertilizer nutrients, eg. N or P, as the other fertilizer nutrient was also increased. A negative interaction term indicates a decrease in leaf N as both nutrients are applied at heavier rates.

In general, Equation 1, in which Y was leaf N concentration, resulted in high multiple correlation square values, ranging from .315 to .862 with a mean R^2 of .538 in 1967 and .716 in 1968.

Table 26 lists the RC's obtained at each site from Equation 1, in which Y, the dependent variable, was leaf P concentration. At most sites, applied N and/or P increased leaf P content while applied K decreased leaf P. Of the sixteen significant RC's to the linear N term, 14 were positive. At most of these sites the quadratic term was significant and negative, indicating slower rate of increase in leaf P due to the N application as the rate of applied N increased. At eighteen sites, the applied P linear term was

Table 26. Regression coefficients and R^2-values obtained from fitting a second degree polynomial with interactions to leaf P concentrations from each site

Regression coefficient[a]	Site number 02	03	04	05
b_o	0.27284	0.24825	0.26580	0.29934
$b_1(N)$	-0.04405++	0.02231	-0.01193	-0.03438
$b_2(N^2)$	0.00135*	0.00059++	-0.00114++	0.00042
$b_3(P)$	0.22647*	0.06944	0.01073	0.28775+++
$b_4(P^2)$	-0.00431	-0.00617+	-0.00187	0.00416
$b_5(K)$	-0.08091++	-0.05550+	-0.14962+++	-0.04994
$b_6(K^2)$	-0.00048	0.00124+	-0.00109	0.00167
$b_7(NP)$	0.00218++	0.00073	-0.00214+	0.00098
$b_8(NK)$	0.00115+++	0.00082++	-0.00086	-0.00086
$b_9(PK)$	-0.00071	0.00680**	0.00414+	0.00035
R^2	0.623	0.588	0.419	0.378
	06	09	11	12
b_o	0.28020	0.25250	0.27079	0.27716
b_1	0.10400***	0.05776**	-0.00574	-0.03227+
b_2	0.00021	-0.00011	-0.00025	-0.00100*
b_3	0.24600	0.21190**	0.22538	0.34595***
b_4	-0.00604++	0.00022	-0.00280	-0.00394
b_5	-0.05688++	-0.00587	-0.08227*	-0.02754
b_6	-0.00026	-0.00036	0.00124++	-0.00050
b_7	0.00104+	0.00089+	-0.00123++	0.00179++
b_8	0.00036	0.00050+	-0.00044	0.00148*
b_9	0.00028	-0.00360**	-0.00389*	0.00216+
R^2	0.757	0.671	0.682	

[a]Listed RC's have been multiplied by 1000 to conserve space, with the exception of b_o, the regression constant.

Table 26. (Continued)

Regression coefficient	Site number 17	20	21	22
b_o	0.27420	0.28298	0.26271	0.27533
b_1	-0.03595	0.07174++	0.05069+	0.05690+
b_2	0.00101++	-0.00200*	-0.00064+	-0.00089+
b_3	0.24849++	0.35426*	0.02973	0.05190
b_4	0.00873	0.00190	-0.00520	0.00145
b_5	-0.06510	-0.07510+	0.05994	0.03771
b_6	-0.00560*	-0.00161	-0.00158	-0.00054
b_7	0.00051	0.00083	-0.00021	0.00002
b_8	0.00169++	0.00018	0.00056	-0.00030
b_9	0.00011	0.00088	-0.00244	0.00009
R^2	0.490	0.543	0.356	0.172
	23	26	27	29
b_o	0.23294	0.28125	0.28132	0.29937
b_1	-0.03291	0.03809+	0.09554**	0.04065+++
b_2	0.00021	-0.00002	-0.00037	0.00017
b_3	0.75780***	0.49503***	0.32882**	0.11200++
b_4	-0.01849+++	-0.00135	-0.00047	0.00103
b_5	0.10172+	0.05064	-0.00346	0.00573
b_6	-0.00351++	0.00140	0.00044	-0.00037
b_7	0.00398+++	-0.00001	0.00172+	0.00030
b_8	-0.00256*	0.00078+	-0.00084+	-0.00032
b_9	0.00409	-0.00099	-0.00495*	0.00255++
R^2	0.716	0.609	0.676	0.361

Table 27. (Continued)

Regression coefficient	31	32	33	36
b_o	0.28332	0.28923	0.27166	0.29034
b_1	0.07425+++	-0.03124	0.10342*	0.04943+++
b_2	0.00057	0.00093+	-0.00012	-0.00134**
b_3	0.58017***	0.09029	0.35959**	0.76505***
b_4	0.00278	-0.01357++	0.00336	-0.01102*
b_5	0.05360	-0.01784	-0.04734	-0.08606+++
b_6	-0.00007	-0.00180	0.00271++	-0.00033
b_7	0.00023+	0.00207	0.00232++	-0.00130+
b_8	0.00013++	-0.00072	0.00023	0.00044
b_9	0.00017	-0.00631+++	0.00047	-0.00129
R^2				

Regression coefficient	38	39	40	All sites combined
b_o	0.28885	0.26627	0.28434	0.27511
b_1	0.03595+	0.11717**	0.22364***	0.03983**
b_2	-0.00106*	0.00074+	-0.00220*	-0.00027+
b_3	-0.02243	0.75077***	0.27256+++	0.29555***
b_4	0.00178	-0.00182	0.01781+++	-0.00140
b_5	0.00340	-0.13523*	0.12587++	-0.02153
b_6	0.00149	-0.00052	-0.00152	-0.00041
b_7	0.00305*	-0.00213++	0.00258	0.00087++
b_8	-0.00099++	0.00062	-0.00284*	-0.00003
b_9	-0.00152	0.00334+	0.00417+	0.00022
R^2	0.462	0.785	0.764	

significant and positive; most of these were significant at the 1% level of probability. The nonsignificant RC's, four of which were positive, occurred on sites with high levels of soil P. Most of the fertilizer P quadratic terms, 17 of 23, were nonsignificant, indicating a near linear increase to applied P even at high rates of P application. An adverse effect of applied K on leaf P did not occur generally. However, at nine sites the linear K RC's were significant and negative, in contrast to only two sites at which the RC's were significant and positive. The quadratic K term was generally nonsignificant. A positive NP interaction was apparent at many of the sites, 17 of 23. This indicates that leaf P was increased more by either N or P as the level of the other increased also. At ten of the sites, the positive NP interaction was significant, and at four sites the interaction was significant but negative. The presence or absence of NK and PK interactions was less obvious with approximately equal numbers of sites exhibiting positive as negative RC's.

The multiple correlation values obtained at the 23 sites for leaf P as a function of applied fertility were similar to those for leaf N. The average R^2 value was approximately .590 for both years. Extremes were .172, at a site where the average available soil P level was 85 pp2m, and .871, at a site where the average available soil P level was 8 pp2m.

Leaf K concentrations within sites were not affected by fertilizer as greatly as were leaf N and leaf P, probably because exchangeable soil K levels at most sites were greater than 200 pp2m and most leaf concentrations were greater than 2.0% K, very few less than 1.5% K. Nevertheless, all three applied nutrients tended to increase the leaf K concentration as indicated by Table 27. Applied N increased leaf K at 15 of 23 sites. Eight of these 15 were significant; at 2 sites applied N effected significant decreases in leaf K concentration. Seven sites had increased leaf K due to applied P which were significant in contrast to 2 significant decreases. Twenty of 23 sites had increased leaf K due to added K, of which 13 were significant. One, with approximately 420 pp2m exchangeable soil K in the 0-6" samples, showed a significant decrease in leaf K due to applied K. The N^2, P^2 and K^2 terms were generally nonsignificant. The PK and NK interaction terms were generally positive, but not generally significant at the 30% level of probability.

Variation among sites

The variability in the RC's for each of the leaf content - applied fertilizer multivariate regression equations was tested using the F-ratio, $F = \frac{\text{Among Site MS}}{\text{Within Site Pooled MS}}$. These MS's and resultant F-ratios are given in Appendix B, Table 42.

Table 27. Regression coefficients and R^2-values obtained from fitting a second degree polynomial with interactions to leaf K concentrations from each site

Regression coefficient[a]	Site number 02	03	04	05
b_o	2.3696	2.1794	2.0634	2.2146
$b_1(N)$	0.08685++	0.09337+++	0.08121+	0.04348+
$b_2(N^2)$	-0.00055	0.00023	0.00082	-0.00182**
$b_3(P)$	0.10448	-0.23884++	0.11947	0.04905
$b_4(P^2)$	0.00552	0.00092	0.00243	0.00119
$b_5(K)$	0.08680	0.06424	-0.12535	0.06364+
$b_6(K^2)$	-0.01535	0.00044	-0.00286	-0.00186+
$b_7(NP)$	0.06174*	-0.00613*	-0.00261	0.00145
$b_8(NK)$	0.01358+	0.00020	-0.00105	0.00114++
$b_9(PK)$	0.05922++	0.00183	-0.00165	0.00146
R^2	0.442	0.469	0.259	0.553
	06	09	11	12
b_o	1.9099	1.9145	2.1171	1.9805
b_1	0.06585++	-0.01609	-0.04821++	0.01382
b_2	-0.00095++	-0.00007	0.00012	-0.00160*
b_3	0.15713+	-0.03311	-0.02460	0.18165++
b_4	-0.01390++	-0.00215	-0.00333	0.00390
b_5	0.29572***	0.25323**	0.07938++	0.19372**
b_6	0.00381+++	-0.00144	-0.00292+++	-0.00361+++
b_7	-0.00141	-0.00069	-0.00299+++	0.00035
b_8	0.00092	0.00196++	0.00092	0.00136++
b_9	-0.00203	-0.00075	-0.00052+	0.00078
R^2	0.672	0.460	0.497	0.628

[a]Listed RC's have been multiplied by 100 to conserve space, with the exception of b_o, the regression constant.

Table 27. (Continued)

Regression coefficient	Site number 17	20	21	22
b_o	1.5060	2.7051	2.4715	2.5382
b_1	-0.10818+++	-0.00564	0.06322+++	0.04575
b_2	0.00011	-0.00017	-0.00037	-0.00046
b_3	-0.08574	0.25584+++	-0.02354	0.05117
b_4	0.00344	0.01144++	-0.01159+++	-0.00345
b_5	0.06154	0.09014++	0.25566***	0.07884
b_6	0.00010	-0.00096	0.00044	-0.00190
b_7	-0.00267	0.01503	0.00559	0.00342++
b_8	-0.00108	-0.01880*	-0.00027	0.00062
b_9	0.00198	0.01157	0.00281+	0.00045
R^2	0.273	0.500	0.671	0.299
	23	26	27	29
b_o	2.3883	2.3535	2.3979	2.6787
b_1	0.03836+	0.02985	-0.00495	-0.00454
b_2	-0.00032	0.00065	0.00014	0.00100+
b_3	0.12683+	0.26427++	-0.04768	-0.00922
b_4	0.00062	-0.00030	-0.00819++	-0.00440
b_5	0.25185***	0.31167**	0.14342**	-0.01687
b_6	-0.00054	-0.00056	0.00059	-0.00138
b_7	0.00176+	0.00395+++	0.00128+	0.00200
b_8	-0.00020	0.00132+	0.00021	-0.00101
b_9	0.00514+++	-0.00134	0.00368+++	0.00278
R^2	-0.569		0.546	0.210

Table 27. (Continued)

Regression coefficient	Site number 31	32	33	36
b_0	2.4300	2.2951	2.2304	2.3648
b_1	-0.02532	0.01863	0.00801	0.05081+++
b_2	-0.00008	0.00023	0.00119*	0.00087+++
b_3	-0.15640+	-0.07538	0.18721+++	0.14474++
b_4	-0.00650	-0.00386	0.00215	0.00914++
b_5	-0.03637	0.19370**	0.19332***	0.13363*
b_6	-0.00187++	-0.00187++	-0.00412**	-0.00167+
b_7	-0.00150	-0.00051	-0.00183++	-0.00403**
b_8	-0.00002	-0.00017	0.00151*	0.00181*
b_9	-0.00031	-0.00024	0.00786**	0.00104
R^2	0.200	0.490	0.772	0.698
	38	39	40	All sites combined
b_0	2.3497	2.3626	2.1932	2.2593
b_1	0.01571	0.06120++	-0.03284	0.02076+
b_2	0.00094++	-0.00165*	0.00114+	-0.00002
b_3	0.11735	0.21534++	0.08131	0.06021
b_4	0.01571+++	-0.00671	0.00127	-0.00016
b_5	0.13236+++	0.05702	0.21665+++	0.13000***
b_6	-0.00087	0.00110	0.00101	-0.00089+
b_7	-0.00053	-0.00088	-0.00198	-0.00025
b_8	-0.00098+	0.00091	0.00120	0.00037
b_9	0.00179	0.00193	0.00080	0.00126
R^2	0.445	0.446	0.299	0.038

In general, it showed that nearly every RC for all three equations varied from site to site. This would indicate that environmental factors exert a great influence on the effect which applied fertilizer has on leaf content. In an attempt to determine which environmental factors were exerting this influence, the RC's, b_N, b_P and b_K, from each of the three equations were entered into selected models as dependent variables. Independent variables, which were selected on the basis of simple correlation, were past cropping, soil yield potential, soil N, subsoil N, soil P, subsoil P, soil K, subsoil K, soil pH, stress index No. 3 (Shaw-Laing p/p_o), plant population and the interaction between stress and strand. These multivariate regression equations, the respective values and statistical significance of the RC's, are listed in Appendix B, Table 43.

The variability in effect of applied fertility on leaf N was not completely explained as indicated by low multiple correlation values. Soil N and subsoil N both substituted for fertilizer N in increasing leaf N. No other terms were statistically significant at the 30% level ($t > 1.00$) in this equation. However, trends were present that indicated greater influence of applied N as distance from meadow increased, as soil pH increased and as soil moisture decreased. The influence of applied P on leaf N, which was negative at most sites, became more positive as soil yield potential increased, soil N and subsoil N increased and as subsoil P decreased. The influence of applied K on leaf N, which was also negative, became more positive with distance from meadow and more negative with increasing quantities of soil N subsoil K and plant population.

The influence of applied P and K fertilizers on variability in leaf P was reasonably well explained, but this was not true for the influence of applied N on variability of leaf P. This could indicate that fertilizer N increased leaf P regardless of the environmental conditions present. The effect of applied N did increase as the soil yielding potential increased and decreased as subsoil N increased. The effect of applied K on leaf P, which was generally negative, became more positive as distance from meadow, soil K and subsoil P increased and as soil yield potential, soil N, soil P and subsoil N decreased.

Generalized leaf content equations

Leaf analysis data was combined for all plots at all sites in a manner similar to grain data. The effect of each of four major types of factors, applied fertility, indigenous fertility, management and climate, were determined first, followed by stepwise combination of these factors and the addition of interactions among the variables. Identical models were studied for leaf N, P and K, except the final step, the inclusion of interaction terms. These models, and resultant equations are listed in Appendix A, Table 44. A summary of Table 44, which indicates the degree to which each of the eight models explained variation in leaf content among plots, is given in Table 28.

Applied fertility explained approximately 20 percent of the variability in leaf N concentrations but less than 10% of the variability in leaf P and less than 5% of the variability in leaf K. However, indigenous fertility explained about 35% of the variability in leaf K, 20% of leaf N variability and less than 15% of leaf P variability. As a result, fertility as a whole accounted for about 40% of the variability in leaf N and leaf K but only 20% of that in leaf P. In all three cases applied and indigenous fertility appeared additive and nearly independent from each other in their effects. Factors which had the most positive effect on leaf N were fertilizer N (at a decreasing rate) and soil N. Fertilizer P and K as well as soil P tended to decrease leaf N. Leaf P was increased by increasing amounts of fertilizer N (at a decreasing rate), fertilizer P, soil P and soil pH. A significant positive fertilizer NP interaction was also apparent. Fertilizer K tended to decrease leaf P, but was only statistically significant at the 40% level. Leaf K was increased as fertilizer N, fertilizer K (at a decreasing

Table 28. Multivariate regression models used to determine the factors which influence leaf nutrient content and the relative importance of four groups of factors

Model no.	Independent variables	R^2 Leaf %N	Leaf %P	Leaf %K	Grain yield
1	Applied fertility	.209	.091	.038	.039
2	Indigenous fertility	.192	.138	.362	.155
3	Management	.216	.075	.503	.192
4	Climate	.209	.105	.310	.465
5	1 + 2	.396	.220	.400	.195
6	1 + 2 + 3	.558	.368	.633	.670
7	1 + 2 + 3 + 4	.571	.426	.608	.764
8	1+2+3+4 + interactions	.595	.474	.662	.798

rate), soil K, and soil N increased. Fertilizer P tended to increase leaf K also, but not significantly.

The group of factors studied under the heading of management, which included past cropping, planting time, weed infestation, plant population and soil yielding potential, explained over 50% of the variation in leaf K, 20% of that in leaf N and only 7 1/2% of the variability in leaf P concentrations. Weed infestation decreased the leaf concentrations of all three nutrients; leaf N and K were decreased as distance from meadow increased and as planting date was delayed; leaf N and P were decreased as plant population increased; and increased soil yielding potential, which was highly correlated with indigenous fertility measurements, resulted in higher N, P and K concentrations.

Increased soil moisture, as indicated by the Shaw-Laing relative photosynthesis index, resulted in increased leaf N and P, but leaf K decreased as climatic conditions became more favorable. An equation containing this index and its quadratic explained 20%, 10%, and 30% of the variability in leaf N, P and K concentrations, respectively. This is in contrast to the 46% of yield variability which was explained by climate.

The addition of management factors to fertility factors resulted in respective R^2 values for leaf N, P and K, of approximately .55, .35 and .65, with little further increase upon the addition of the climatic index. It is believed that the low R^2 for leaf P, relative to leaf N and K, is partially due to laboratory errors in the determination of leaf P concentrations.

The addition of interaction terms, based primarily on simple correlations and the results obtained by Voss (1962) and Dumenil (1958), resulted in respective R^2 for leaf N, P and K of 0.60, 0.47 and 0.66. The final equations for each of these as a function of controlled and uncontrolled factors are given in Tables 29, 30 and 31.

Inspection of the leaf N equation reveals that fertilizer N increased leaf N at a linear rate, fertilizer P decreased leaf N at a decreasing rate (less decrease at higher rates of P), and fertilizer K decreased leaf N but not significantly. Increased leaf N was associated with increasing soil pH. The net effect of soil N and soil P was not obvious. Leaf N decreased as distance from meadow increased, increased as soil yield potential decreased, decreased as plant population increased and increased as soil moisture increased. Most of the suggested interactions between fertilizer N and uncontrolled variables were not significant. However, soil N did substitute for fertilizer N in increasing leaf N and the negative effect of plant population decreased at higher rates of N.

Factors which affect the change in leaf N as influenced by fertilizer N, and their respective directions of effect are illustrated by the partial derivative of the leaf N equation taken with respect to fertilizer N. This equation becomes

$$\begin{aligned}\frac{\partial N_1}{\partial N} = {} & 0.20054 - 0.00178\,N - 0.00573R - 0.00278n \\ & -0.0019D + 0.00832S + 0.0004RN = 0.00006n_sN \\ & -0.00002CN + 0.00002DN.\end{aligned} \tag{9}$$

Table 29. A generalized leaf N concentration equation containing controlled and uncontrolled variables and interactions among them

Regression variate	Regression coefficient	t-value
b_o	0.05232	
N	0.20054	2.22*
N^2	-0.00089	0.35
P	-0.05256	1.62++
P^2	0.00231	1.34++
K	-0.00724	0.44
n	-0.15107	2.32*
p	0.35094	2.72***
k	0.05296	4.29***
a	15.48900	7.26***
n_s	-0.04430	0.16
P_s	-2.62760	7.20***
R	-15.55500	3.96***
T	-0.03349	0.19
W	-4.84470	4.23***
C	2.01510	7.40***
S	-0.85722	2.89**
B	-0.59332	5.63***
R^2	2.52920	3.89***
D	0.90336	3.49***
D^2	-0.02001	4.94***
RN	-0.00573	0.66
nN	-0.00278	3.42***
DN	-0.00019	0.28
RN^2	0.00002	0.14
n_sN^2	0.00003	0.85
CN^2	-0.00001	0.42
DN^2	0.00001	1.23+
SN	0.00832	2.27*

$R^2 = 0.595$ Standard error = 0.166

Table 30. A generalized leaf P concentration equation containing controlled and uncontrolled variables and interaction among them

Regression variate	Regression coefficient	t-value
b_o	0.001421	
N	0.25865	1.63++
N^2	-0.00045	2.49*
P	0.77502	3.35***
P^2	-0.00973	2.06*
K	-0.01096	0.59
n	-0.34887	4.64***
p	0.21634	2.18*
k	0.04657	3.23**
a	23.58900	8.32***
n_s	-0.03509	4.03***
P_s	-0.02344	0.06
a_s	4.80230	1.33++
R	-27.24120	6.24***
W	-7.99009	6.25***
S	-1.27090	2.94**
C	1.48778	5.16***
B	-0.13381	1.04+
R^2	4.27573	5.76***
S^2	0.01000	0.52
D	2.08494	7.02***
D^2	-0.02707	5.64***
RN	-0.01066	1.09+
an	-0.02948	1.18+
DN	-0.00019	0.25
p_sP	-0.01785	1.95+++
pP	-0.00246	0.87
nP	0.00118	0.40
DP	-0.00703	2.82**
pP^2	0.00011	1.12+
D^2P^2	0.000003	1.83++

R^2 = 0.474 Standard error = 0.018

Table 31. A generalized leaf K concentration equation containing controlled and uncontrolled variables and interactions among them

Regression variate	Regression coefficient	t-value
b_o	0.72311	
N	0.04646	0.86
P	0.05033	1.70+++
K	0.23310	4.37***
K^2	-0.00080	2.05*
NK	-0.00130	1.28+
n	-0.34678	5.71***
p	-0.05402	0.84
k	0.13148	11.4***
a	6.74370	3.24**
n_s	0.41569	2.22*
P_s	0.29076	0.96
k_s	-0.32503	2.98**
R	-23.86400	6.76***
T	-1.03750	5.96***
W	-4.18950	4.14***
S	0.00039	1.42++
C	1.25290	6.11***
B	0.18776	1.89+++
R^2	3.73100	6.21***
D	-0.31072	3.77***
H	0.57960	0.43
RN	0.00526	0.67
nN	-0.00066	0.88
RK	-0.00743	0.57
kK	-0.00042	2.30*
nNK	0.00003	1.74++

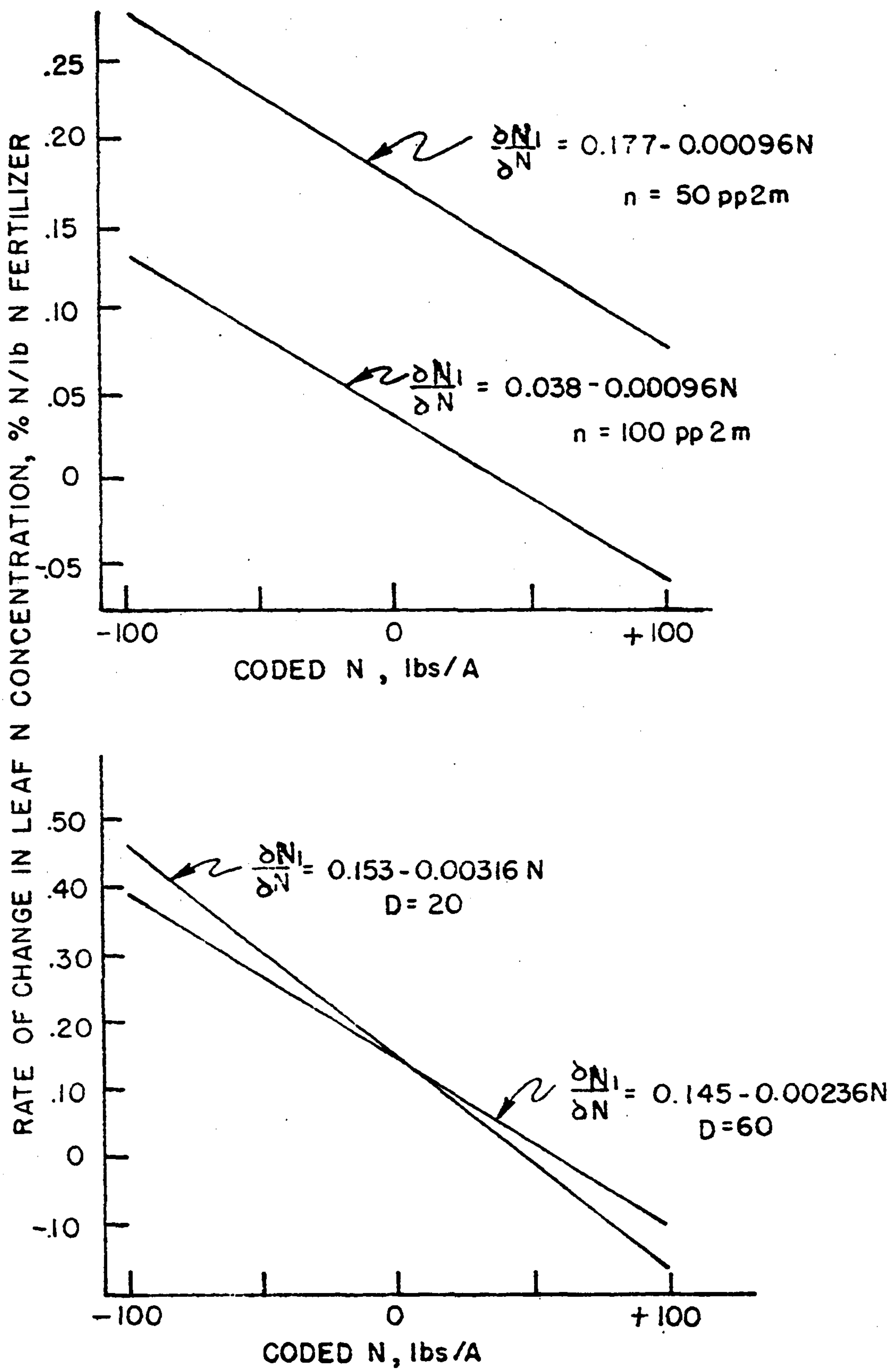
R^2 = 0.662 Standard error = 0.191

Changes in fertilizer N, past cropping, soil N, soil moisture and stand influenced the effect of fertilizer N on leaf N concentrations, while past cropping, subsoil N, soil yield potential and soil moisture affected the rate at which leaf N changed with the addition of more fertilizer N.

Figure 9A illustrates the change in leaf N at two levels of soil N. The rate of change at the two levels of soil N is identical. That is each additional increment of N increased leaf N less (or decreases it more). But, the magnitude of changes were different. At the lower level of soil N, additional fertilizer N continued to increase leaf N concentration throughout the entire range of applied N, 0 to 200 lbs/A. At the higher level of soil N, additional fertilizer N increased leaf N up to about 140 lbs. Rates above this decreased leaf N below the maximum, which was predicted to be at the 140 lb. rate. Average experimental values for the other variables in the rate of change equation were used in illustrating the specific effect of soil N.

Figure 9B illustrates the effect of soil moisture, or lack of it, as indicated by the Laing-Shaw relative photosynthesis index, on the change in leaf N concentration with increasing rates of fertilizer change. Under high stress (D = 20), the lower rates of fertilizer N increased leaf N more than at low stress. But, the rate of change was greater

Figure 9. Rate of change equation of leaf N concentration with respect to fertilizer N at two levels of soil N and two levels of relative photosynthesis



RATE OF CHANGE IN LEAF N CONCENTRATION, % N/lb N FERTILIZER
.25
.20
.15
.10
.05
0
-.05
$\frac{\partial N_1}{\partial N} = 0.177 - 0.00096N$
n = 50 pp2m
$\frac{\partial N_1}{\partial N} = 0.038 - 0.00096N$
n = 100 pp2m
-100
0
+100
CODED N, lbs/A
.50
.40
.30
.20
.10
0
-.10
$\frac{\partial N_1}{\partial N} = 0.153 - 0.00316N$
D= 20
$\frac{\partial N_1}{\partial N} = 0.145 - 0.00236N$
D=60
-100
0
+100
CODED N, lbs/A

under high stress, so at high rates of N, the increase in leaf N was less than at low stress (or, the decrease in leaf N was greater at low stress) as fertilizer N increased. In both cases, maximum leaf N occurred at about 150 lbs/A of fertilizer N.

The final leaf P equation, given in Table 30, has an R^2 of only 0.474, not as high as the leaf N and leaf K equations. This is thought to be the result of three factors. First, many sites were well supplied with soil P which resulted in uniform leaf P concentrations on all plots within these sites. Second, the laboratory error associated with leaf P determination was not considered as small as for leaf N and K determinations. Third, there may be factors in the environment which influenced leaf P concentrations but which were not measured in this experiment. However, many significant factors were detected. Among the factors which increased leaf P were increasing fertilizer N (at a decreasing rate), fertilizer P (at a decreasing rate) soil P, soil K, soil pH, soil yield potential and soil moisture. Leaf P concentration decreased with increasing plant population, weed growth, soil N and distance from meadow. The positive effect of fertilizer P was less at higher soil P, indicating substitution, and at higher soil moisture. Fertilizer P increased leaf P less as soil moisture increased.

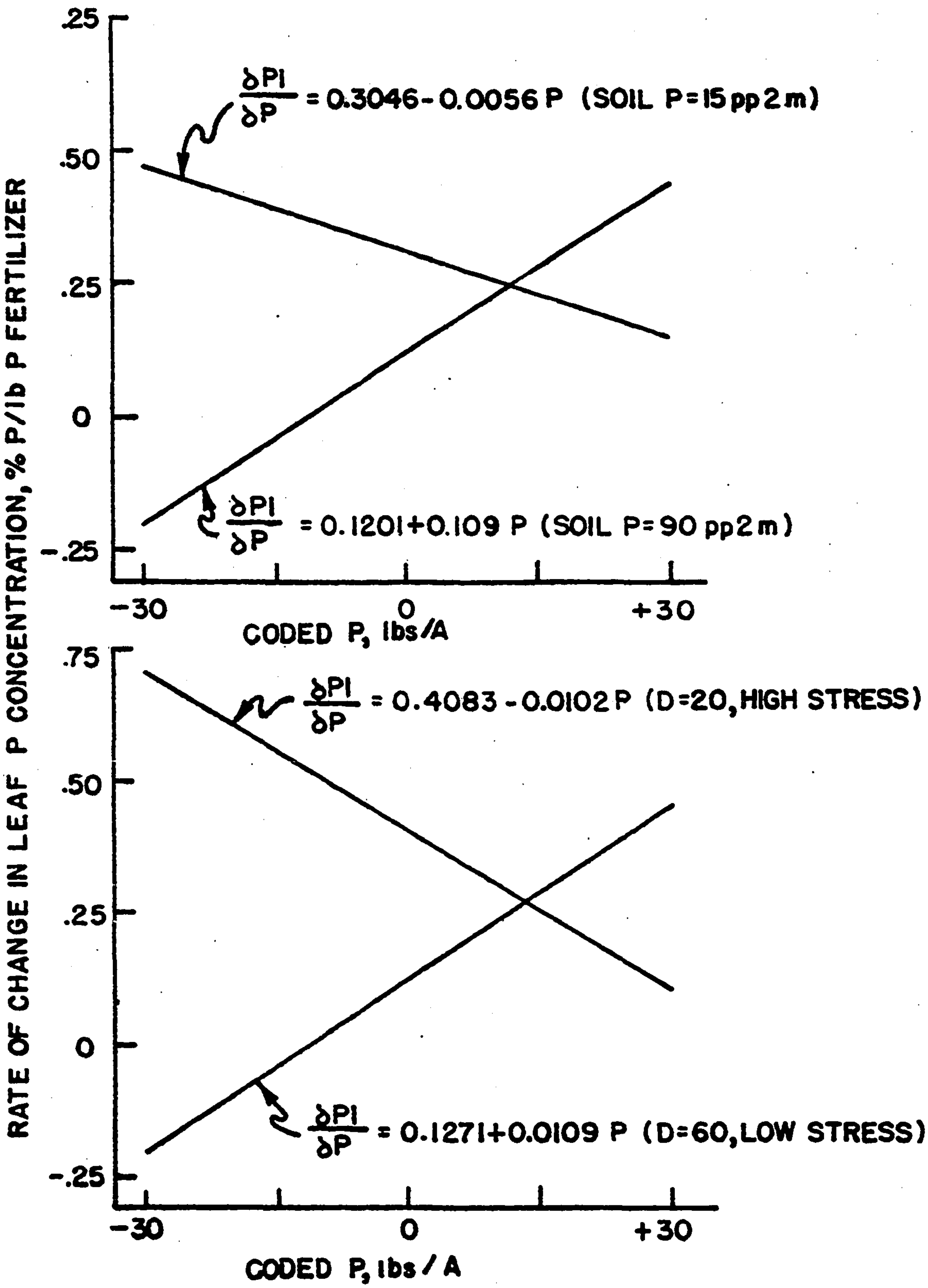
A graphic illustration of which factors affected the influence of fertilizer P on leaf P is accomplished through the partial derivative of the leaf P equation taken with respect to fertilizer P.

$$\frac{\partial P_l}{\partial P} = 0.7750 - 0.0195P - 0.0178\ p_s - 0.0025\ p \quad (10)$$
$$+ 0.0012n - 0.0070D + 0.00022_p P + 000007D^2P$$

Figure 10A illustrates the influence of fertilizer P on leaf P at two levels of soil P, while the other variables are held at their approximate average level (P_s = 12.5 pp2m, n = 60 pp2m and D = 40). It is seen that at low soil P, increasing amounts of fertilizer P increased leaf P concentration throughout the range used in this experiment, 0-60 pounds per acre, but at a decreasing rate. On the contrary, at high soil P, the initial increment of applied P decreased leaf P but the negative effect became more positive as rates of P increased with the minimum leaf P concentration predicted at 20 lbs per acre applied P. All rates above 20 lbs per acre increased leaf P concentrations according to this prediction equation.

Figure 10B illustrates the effect of soil moisture on the response by the leaf to increasing rates of P. In this figure the average values for subsoil P (12.5 pp2m), soil N (60 pp2m) and soil P (30 pp2m) were maintained. At high

Figure 10. Rate of change equation of leaf P concentration with respect to fertilizer P at two levels of soil P and two levels of relative photosynthsis


RATE OF CHANGE IN LEAF P CONCENTRATION, % P/lb P FERTILIZER
.25
.50
.25
0
-.25
δPI/δP = 0.3046-0.0056 P (SOIL P=15 pp2m)
δPI/δP = 0.1201+0.109 P (SOIL P=90 pp2m)
-30
0
+30
CODED P, lbs/A
.75
.50
.25
0
-.25
δPI/δP = 0.4083-0.0102 P (D=20, HIGH STRESS)
δPI/δP = 0.1271+0.0109 P (D=60, LOW STRESS)
-30
0
+30
CODED P, lbs/A

stress (D = 20) increasing rates of P increased leaf P concentrations, even up to 60 lbs per acre, at a decreasing rate. This effect is similar to low soil P. At low stress (D = 60), the effect was similar to high soil P. The first 20 pounds per acre of applied P decreased leaf P but rates above this increased leaf P concentration at an increasing rate.

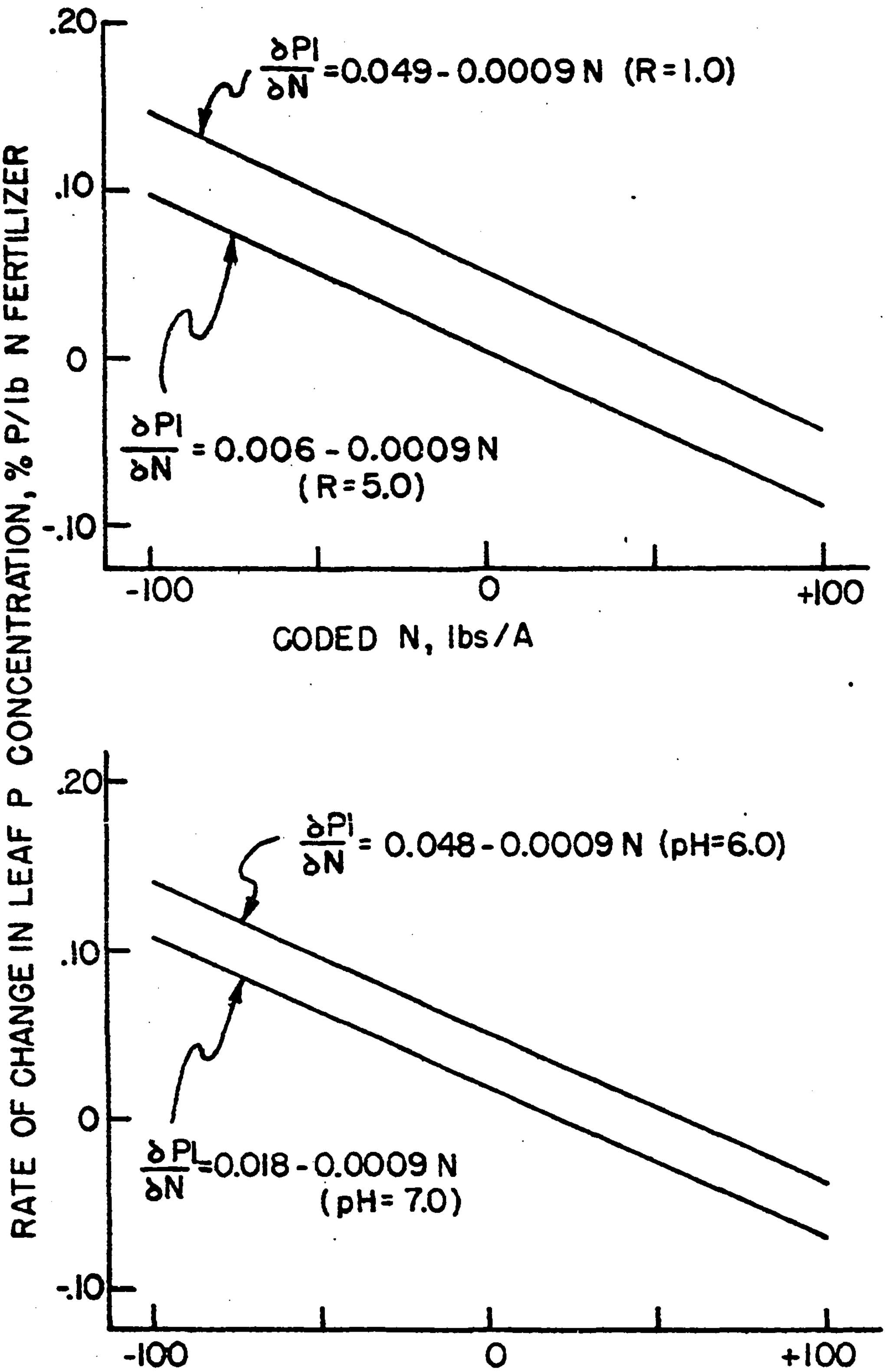
The effect of applied N on leaf P concentration is illustrated by

$$\frac{\partial P_l}{\partial N} = 0.25865 - 0.009N - 0.01066R - 0.02948a \quad (11)$$

$$-0.00019D$$

Figure 11A illustrates the effect of applied N at two levels of past cropping, with soil pH at 6.5 and the relative photosynthesis stress index, D, at 40. At all levels of N, applied N increased leaf P more in first year corn after meadow than fifth year continuous corn. The rate of change slope was the same in both cases with maximum leaf P predicted at 150 lbs/A and 100 lbs/A for first and fifth year corn, respectively. These results appear contrary to what might be expected, since first year meadow should have more nitrogen already available in the soil. Thus, applied fertilizer would be expected to have less effect on first than fifth year corn. This can possibly be explained by the fact that the first year corn sites used in this experiment

Figure 11. Rate of change of leaf P concentration with respect to fertilizer N at two levels of past cropping and at two levels of soil pH


RATE OF CHANGE IN LEAF P CONCENTRATION, % P/lb N FERTILIZER
.20
.10
0
-.10
-100
0
+100
CODED N, lbs/A
δPl/δN =0.049-0.0009 N (R=1.0)
δPl/δN = 0.006-0.0009 N
(R=5.0)
δPl/δN = 0.048-0.0009 N (pH=6.0)
δPl/δN =0.018-0.0009 N
(pH= 7.0)

were considerably lower in available phosphorous than the more continuous corn sites.

Figure 11B illustrates the effect of soil pH on the influence of applied N towards leaf P. A greater positive influence by N was exerted as soil pH decreased. This effect was small, but it was significant. Maximum leaf P was predicted at 160 lbs/A for pH of 6.0 and 120 lbs/A for pH of 7.0.

The final leaf K equation, Table 31, resulted in an R^2 of 0.662, higher than either leaf N or leaf P. Despite the high soil K levels on nearly all plots, a range of leaf K concentrations of 1.3% to 3.0% were measured. Leaf K was increased with increasing fertilizer N, fertilizer P, fertilizer K, soil K, soil pH, soil yield potential and plant population. It was decreased by increasing distance from meadow, weeds and soil moisture. Significant interactions were few, but the positive effect of fertilizer K was less at higher rates. The negative NK interaction indicates less increase due to fertilizer K at higher rates of N. This interaction was influenced by soil N, also. Soil K substituted for fertilizer K in its effect on leaf K.

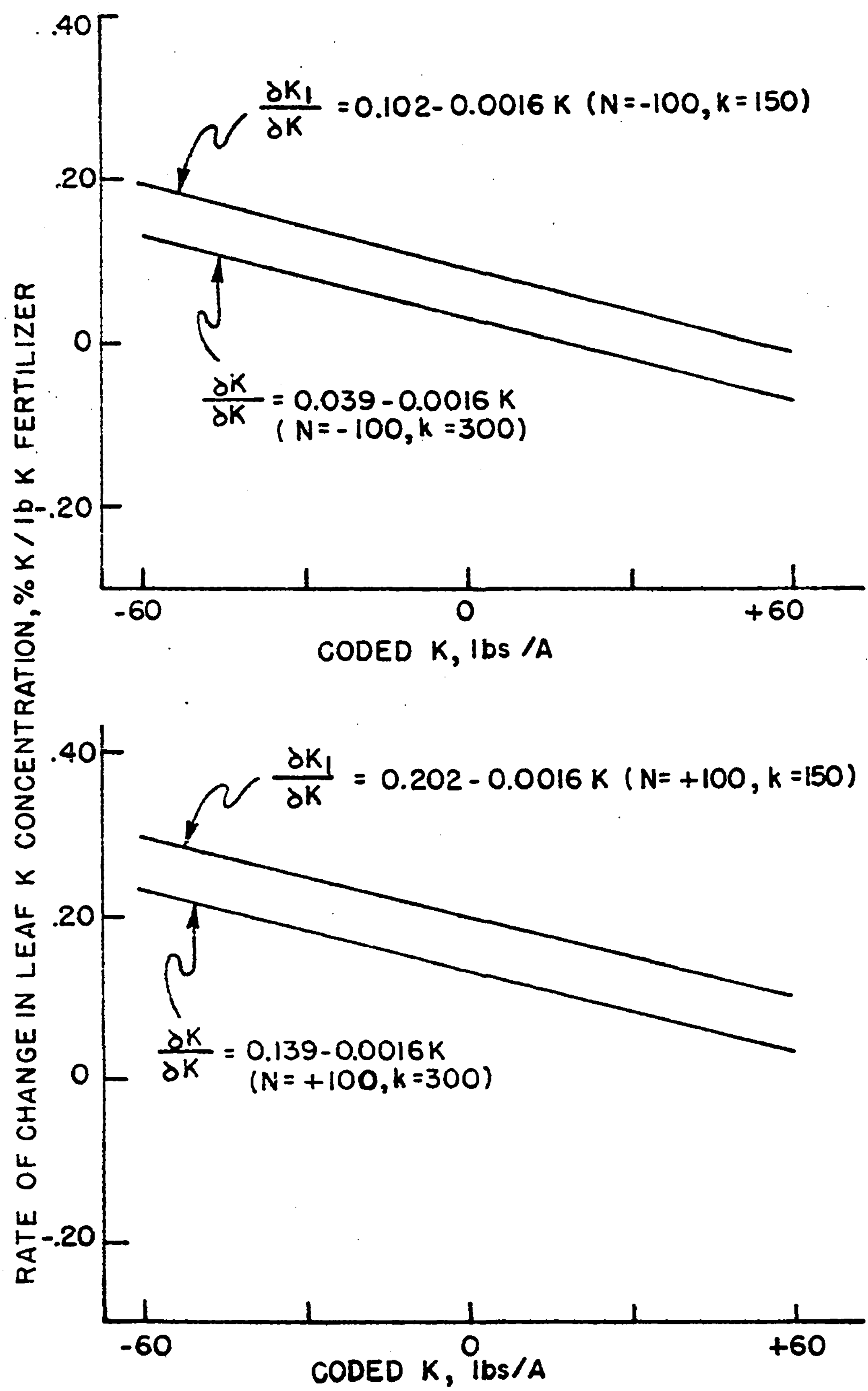
The change in leaf K as effected by fertilizer K is indicated by the derivative of the leaf K equation with respect to fertilizer K.

$$\frac{\partial K_1}{\partial K} = 0.23310 - 0.00160K - 0.00130N -0.00743R - 0.00042k + 0.00003nN \qquad (12)$$

It is seen that at zero inputs of all other variables, additional fertilizer K increases leaf K. This increase becomes less positive as K, N, R and k are increased. Figure 12 shows the rate of change in leaf K with respect to fertilizer K at two levels of soil K and two levels of fertilizer N, while past cropping, R, and soil N, n, are maintained at their average levels, 2.5 and 60 pp2m, respectively. These figures illustrate that fertilizer K increased leaf K more when soil K was low and fertilizer N was high than when soil K was high and fertilizer N was low. The equation predicted maximum leaf K to be at 120 lbs/A of fertilizer K under all conditions except when soil K was high (300 pp2m) and fertilizer N low (0 lbs/A), at which approximately 80 lbs/A of K gave maximum leaf K concentration.

The effect of past cropping was not in the direction which was expected. It was expected that the return of corn stover to the soil would result in more potassium available to the plant and, thus, higher leaf K, in contrast to fields which were meadow the previous year. This increased potassium from continuous corn was probably reflected in soil test data, however. The continuous corn sites were generally higher in exchangeable soil K, but this is more likely a reflection of soil type than past cropping. The simple correlation between soil K and soil yield potential was 0.52, while between soil

Figure 12. Rate of change of leaf K concentration with respect to fertilizer K at two levels of soil K and two levels of applied N



RATE OF CHANGE IN LEAF K CONCENTRATION, % K / lb K FERTILIZER
.40
.20
0
-.20
$\frac{\delta K_1}{\delta K}$ = 0.102 - 0.0016 K (N=-100, k=150)
$\frac{\delta K}{\delta K}$ = 0.039 - 0.0016 K (N=-100, k=300)
-60
0
+60
CODED K, lbs /A
.40
.20
0
-.20
$\frac{\delta K_1}{\delta K}$ = 0.202 - 0.0016 K (N=+100, k=150)
$\frac{\delta K}{\delta K}$ = 0.139 - 0.0016 K (N=+100, k=300)
-60
0
+60
CODED K, lbs/A

K and past cropping was 0.23. The rate of change in leaf K as influenced by past cropping is given by

$$\frac{\partial K_1}{\partial R} = -23.864 + 3.731 R + 0.00526N - 0.00743K, \qquad (13)$$

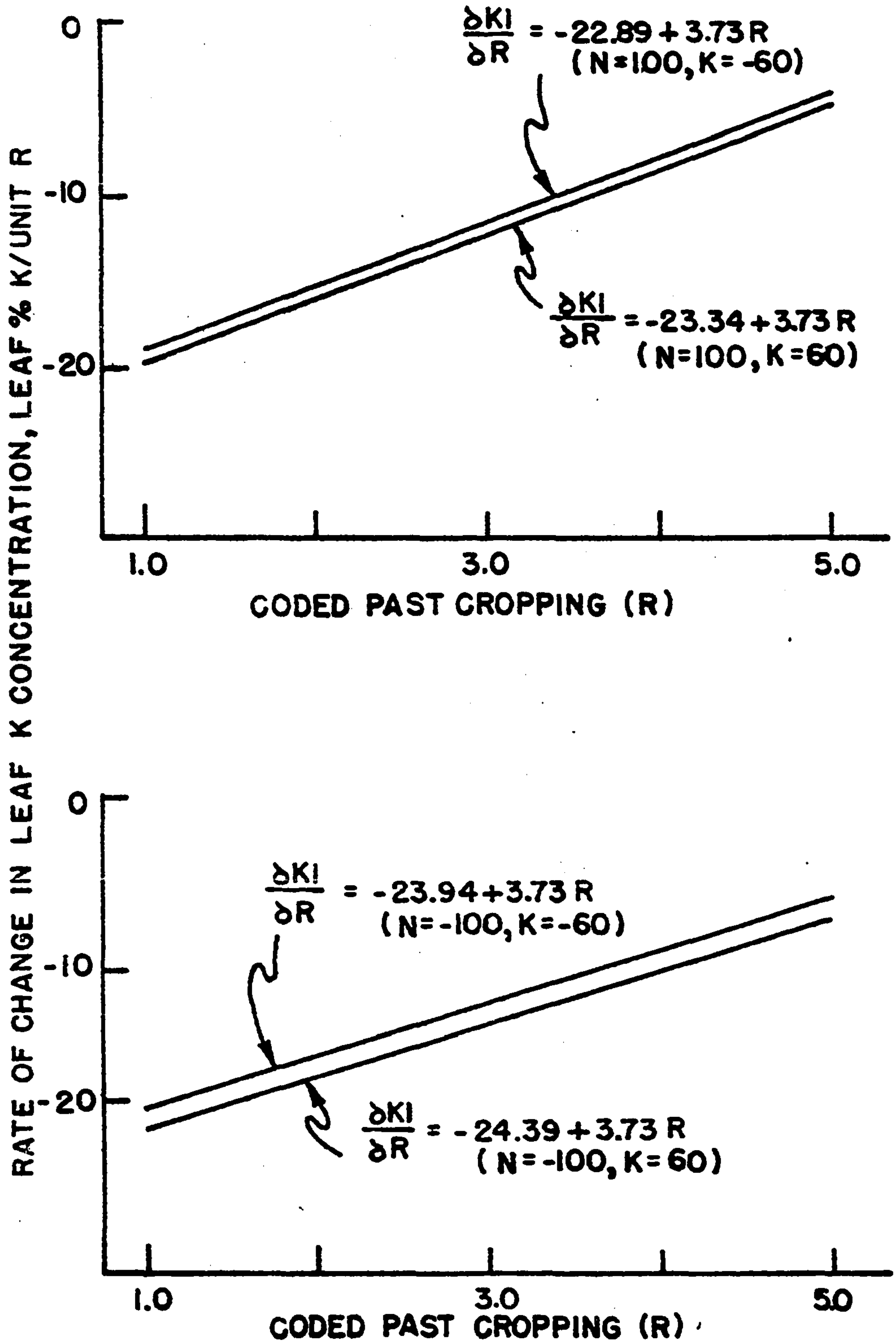
and illustrated in Figure 13. This figure illustrates the negligible influence of fertilizer N and K on the effect of decreased leaf K due to distance from meadow. The figure also illustrates that within the ranges of this experiment, the influence of distance from meadow was negative, but less negative as distance increased.

Relationship Between Grain Yield and Leaf Content

The ultimate purpose of plant analysis is to assess the nutritional status of the plant which is assumed to be an indicator of plant yielding potential. The results of this experiment indicate very strongly that this latter assumption is conditional upon other factors not being limiting.

In development of a leaf content - grain yield relationship, easiest interpretations will be possible if the relationship is simple. Thus, a regression equation was sought which would afford the maximum information with the fewest number of "independent" variables. A series of multiple regression models were fitted to the N, P and K leaf concentrations of leaves from each plot. These models increased from 3 to 21

Figure 13. Rate of change of leaf K concentration with respect to past cropping at two levels of fertilizer N and two levels of fertilizer



RATE OF CHANGE IN LEAF K CONCENTRATION, LEAF % K/UNIT R
0
-10
-20
$\frac{\partial KI}{\partial R} = -22.89 + 3.73R$
(N=100, K=-60)
$\frac{\partial KI}{\partial R} = -23.34 + 3.73R$
(N=100, K=60)
1.0
3.0
5.0
CODED PAST CROPPING (R)
0
-10
-20
$\frac{\partial KI}{\partial R} = -23.94 + 3.73R$
(N=-100, K=-60)
$\frac{\partial KI}{\partial R} = -24.39 + 3.73R$
(N=-100, K=60)
1.0
3.0
5.0
CODED PAST CROPPING (R)

"independent" variabiles. These models and their resultant equations are listed in Table 32.

Model number 1 contains only the linear leaf N, P and K terms. It has a low R^2, only 0.184, and thus deemed unsatisfactory. Model 2 contains the linear and quadratic leaf N and P terms and the leaf N by P interaction term. Leaf K was omitted because the average leaf K concentration was 2.25%, with very few below 2.00%. The critical level has been predicted to be 1.5-1.9% by various investigations. Thus, it was assumed that leaf K content would not be important in deriving a grain yield - leaf concentration relationship. However, Model 2 resulted in an R^2 of only 0.091, while Model 3, which included leaf linear and quadratic terms, resulted in an R^2 of 0.238. Still this could not be considered a satisfactory relationship. Thus, Models 4 and 5 include several uncontrolled variables as linear terms and as interaction terms with leaf nutrient concentrations. The variables included were past cropping, plant population, soil yield potential, relative photosynthesis stress index, barrenness and the dummy moisture variable (used at site 40 only). The latter two variables were not entered as interactions.

Model 4 does not contain leaf K and K^2 terms, while Model 5 does contain them. The respective resultant R^2's were 0.715 and 0.721, which are within 0.10 of the R^2 from the final yield equation discussed in Part I. Since Model 5 does

Table 32. Stepwise multivariate regression equations used to evaluate the relationship between yield and leaf nutrient concentrations

Model no.	Regression variates	Regression coefficients	t-value	R^2	Standard error
1	b_o	105.653		.184	22.6
	N_1	-3.63252	0.83		
	P_1	246.417	5.45***		
	K_1	-30.0621	9.94***		
2	b_o	-194.240		.091	23.9
	N_1	98.7317	1.77+++		
	N_1^2	-46.5631	4.01***		
	P_1	1085.45	2.03*		
	P_1^2	-4160.41	3.79***		
	N_1P_1	516.737	2.61**		
3	b_o	-125.085		.238	21.9
	N_1	42.3480	0.82		
	N_1^2	-42.7919	4.01***		
	P_1	778.404	1.58++		
	P_1^2	-4406.16	4.37***		
	K_1	64.4527	2.35*		
	K_1^2	-21.7261	3.44***		
	N_1P_1	684.431	3.75***		
4	b_o	341.893		.715	13.6

Table 32. (Continued)

Model no.	Regression variates	Regression coefficients	t-value	R^2	Standard error
	N_1	-31.7906	0.46		
	N_1^2	-28.5943	3.26**		
	P_1	-792.558	1.32++		
	P_1^2	-3488.16	3.47***		
	N_1P_1	530.830	3.52***		
	R	14.7313	1.55++		
	S	3.40400	0.97		
	C	-3.13341	2.26*		
	D	-3.26162	5.01***		
	B	-1.01349	12.3***		
	H	-6.96474	6.50***		
	RN_1	7.35008	2.70**		
	SN_1	1.07800	0.94		
	CN_1	-0.17938	0.30		
	DN_1	0.83373	3.11**		
	RP_1	-127.452	3.74***		
	SP_1	-21.6620	1.71+++		
	CP_1	16.8700	2.54*		
	DP_1	7.89025	3.11**		
5	b_o	321.145		.721	13.4
	N_1	-11.3994	0.17		
	N_1^2	-17.4278	3.15**		

Table 32. (Continued)

Model no.	Regression variates	Regression coefficients	t-value	R^2	Standard error
	P_1	-671.427	1.12+		
	P_1^2	-3646.23	3.65***		
	K_1	-65.3974	3.51***		
	K_1^2	15.3406	3.54***		
	N_1P_1	521.641	3.49***		
	R	11.7590	1.24+		
	S	3.44318	0.99		
	C	-2.11062	1.50++		
	D	-3.61000	5.53***		
	B	-1.06952	12.8***		
	H	-6.66220	6.24***		
	RN_1	6.97939	2.58**		
	SN_1	1.18772	1.04+		
	CN_1	-0.44342	0.75		
	DN_1	0.83330	3.13**		
	RP_1	-114.658	3.33***		
	SP_1	-22.9219	1.82+++		
	CP_1	16.1797	2.45*		
	DP_1	9.25882	3.64***		

not appear to greatly improve the relationship over Model 4, Model 4 was used to determine predicted effects of the variables as they changed in values.

The optimum levels of leaf N and leaf P, concentrations at which maximum yield is predicted, can be determined by taking the partial derivatives of yield with respect to leaf N and leaf P, respectively, equating each resultant equation with zero, and solving them as simultaneous equations. The respective equations are, as follows:

$$\frac{\partial Y}{\partial N} = -31.8 - 57.2N + 530.8P + 7.4R + 1.1S - 0.83D$$

$$\frac{\partial Y}{\partial P} = -792.6 - 6976.4P + 530.8N - 127.5R - 21.7S + 16.9C + 7.9D, \qquad (14)$$

where N and P represent leaf N and leaf P concentrations, respectively. In order to obtain unique solutions for N and P, constant values for R, S, C and D must be selected. Thus, the optimum levels of leaf N and leaf P are dependent upon past cropping, plant population, soil yielding potential and soil moisture. If the approximate average experimental values are used (R = 2.5, S = 16.5, C = 100 and D = 40), the optimum levels of leaf N and leaf P are predicted to be 3.60% and .350%, respectively. The corresponding maximum yield is 114.7 bu/A. These levels of leaf N and leaf P appear to be somewhat higher than values generally used in the past.

However, further inspection of the equation reveals that, near the optimum levels, very small yield increases result from large increases in leaf concentrations. For example, 90% of the optimum leaf concentrations (N = 3.25%, P = .315%) predicts a yield of 113.5 bu/A, 99% of the maximum predicted yield at 100% of optimum leaf concentrations. Furthermore, 80% of the optimum leaf concentrations (N = 2.90%, P = .280%) predicts 95% of the maximum yield. At nutrient levels below these, yield levels decrease more rapidly.

The changes in optimum leaf concentrations as the uncontrolled variables change can be illustrated by varying the value of one uncontrolled variable while maintaining the others at a constant level. The optimum leaf concentrations can then be determined at each level of the changing variable through simultaneous equations, as illustrated in previous discussion.

Figure 14A illustrates the changes in optimum leaf N and P concentrations as past cropping (R) was varied from first year to fifth year corn after meadow. Equation 4 predicts that both optimum N and P requirements are higher in first year corn. The relative change in leaf P was much greater than in leaf N. Each additional year of corn indicated a decrease in optimum leaf N and P concentrations of 0.15% and 0.03%, respectively.

Figure 14. The change in optimum leaf N and leaf P concentrations as influenced by different past cropping (at average experimental values for S, D and C) and as influenced by varying plant population (at average experimental values for R, D and C)

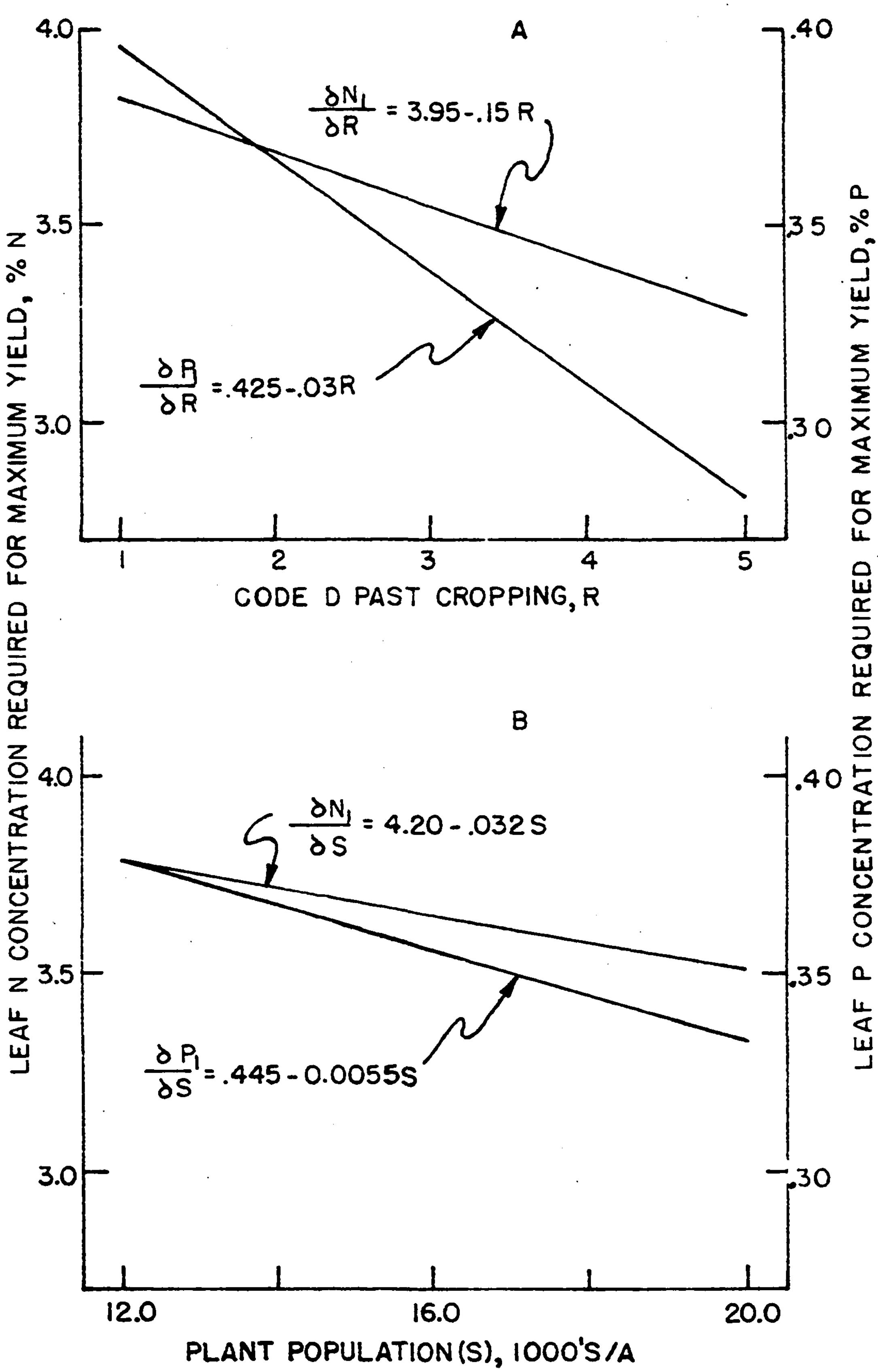

A
4.0
3.5
3.0
.40
.35
.30
$\frac{\delta N_l}{\delta R} = 3.95 - .15R$
$\frac{\delta P_l}{\delta R} = .425 - .03R$
1
2
3
4
5
CODE D PAST CROPPING, R
B
4.0
3.5
3.0
.40
.35
.30
$\frac{\delta N_l}{\delta S} = 4.20 - .032S$
$\frac{\delta P_l}{\delta S} = .445 - 0.0055S$
12.0
16.0
20.0
PLANT POPULATION (S), 1000'S/A
LEAF N CONCENTRATION REQUIRED FOR MAXIMUM YIELD, % N
LEAF P CONCENTRATION REQUIRED FOR MAXIMUM YIELD, % P

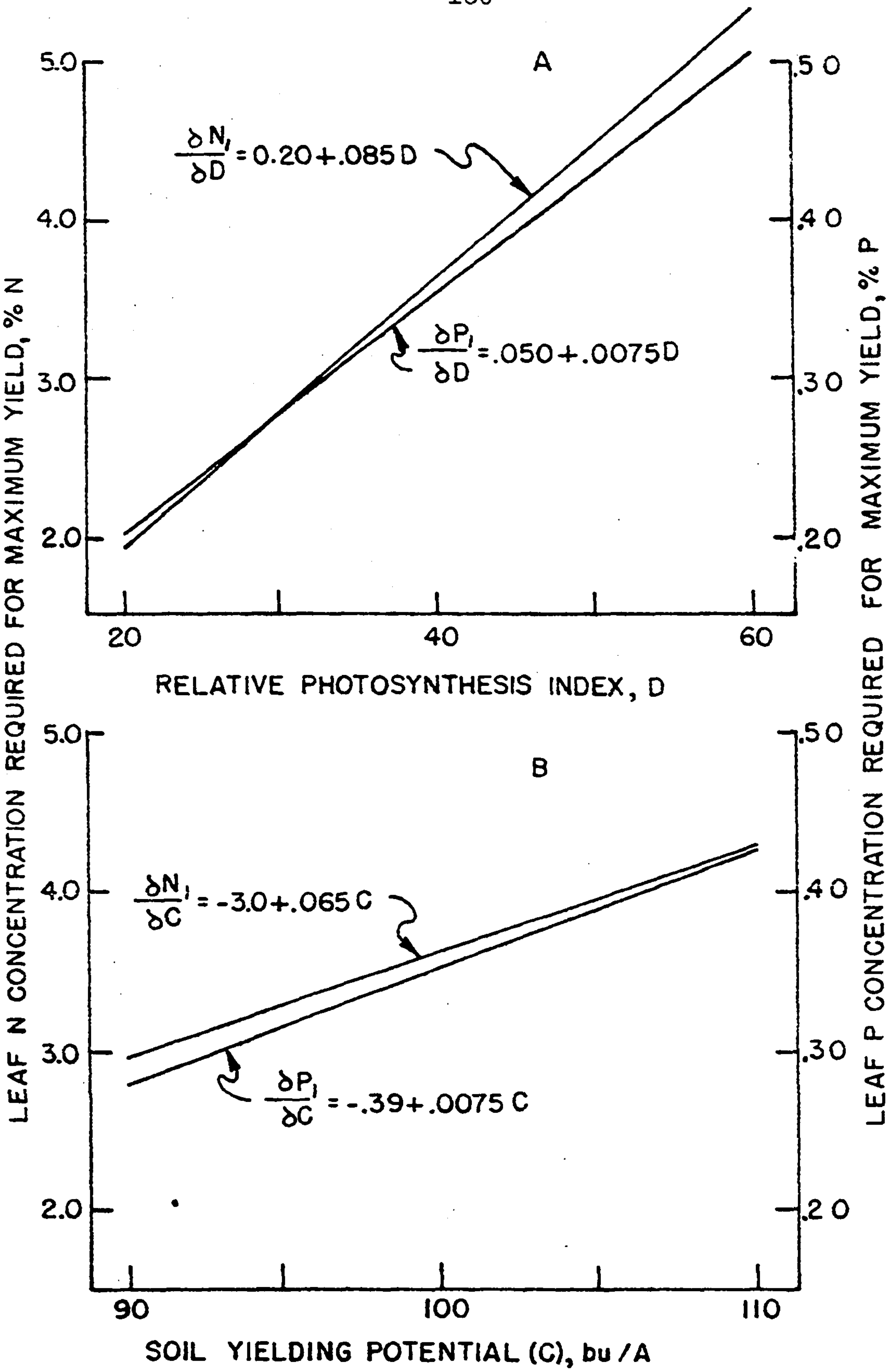
Figure 14B illustrates that the changes in optimum leaf N and P levels as plant population changed were not as great as when past cropping was varied. As plant population increased, optimum levels decreased, but nearly a 10:1 ratio for leaf N:leaf P was maintained. Each increase of 1000 plants resulted in decreased optimum leaf N and P concentrations of approximately 0.03% and 0.006%, respectively.

Figure 15 illustrates that optimum leaf N and P levels increased as soil moisture and soil yielding potential increased. The change as soil moisture changed was very large, a change from 2.0% and 0.20% to 5.0% in leaf N and P, respectively, as the relative photosynthesis index increased from 20 to 60. The 10:1 ratio of leaf N:P was maintained throughout this range.

Figure 15B illustrates that each additional unit increase in soil yielding potential, between 90 and 110 bu/A, resulted in increased optimum leaf N and P concentrations of 0.065% and 0.0075%, respectively.

The above mentioned illustrations, which were derived from an equation with an R^2 of 0.715, are believed to be quite accurate when evaluated near the experimental means for past cropping, plant population, soil moisture stress and soil yielding potentials. However, because the quadratic terms for these variables were not included in the prediction equation, interpretation at the extremes of

Figure 15. The change in optimum leaf N and P concentrations as influenced by varying moisture stress (at average experimental values for R, S and C) and as influenced by varying soil yield potential (at average experimental values for R, S and D)


A
$\frac{\delta N_1}{\delta D} = 0.20 + .085D$
$\frac{\delta P_1}{\delta D} = .050 + .0075D$
RELATIVE PHOTOSYNTHESIS INDEX, D
B
$\frac{\delta N_1}{\delta C} = -3.0 + .065C$
$\frac{\delta P_1}{\delta C} = -.39 + .0075C$
SOIL YIELDING POTENTIAL (C), bu/A
LEAF N CONCENTRATION REQUIRED FOR MAXIMUM YIELD, % N
LEAF P CONCENTRATION REQUIRED FOR MAXIMUM YIELD, % P

experimentally observed values must be done with caution. However, Figures 14 and 15 do illustrate the direction of change in optimum leaf N and P levels as each of the uncontrolled variables changed and indicate an approximation of the magnitude in change which can be expected.

PART III. ROOTWORM-FERTILITY STUDY

REVIEW OF PAST EXPERIMENTATION

Little information is reported in the literature which indicates that rootworm infestation and subsequent damage are directly related to the fertility status of the soil. However, one recent study does indicate the possibility of such a rootworm-fertility interaction.

Turpin (1968) reported the root damage and size ratings in relation to many soil properties. This study included a sampling of the entire state of Iowa. The plots which were sampled were those of the Corn Yield Study, supervised by Dr. Lloyd Dumenil. Turpin reported that damage ratings, on corn following corn, showed an increasing trend as soil N increased, a definite increase as soil K increased, and no definite trend with increasing soil P. The soil K effect may be confounded with the fact that western Iowa, during the years of his sampling study, was more subject to rootworm infestation. Western Iowa is the area of highest soil K. Thus, the high correlation between rootworm damage and soil K may be without cause and effect.

Because of the possible, but not definite, trends observed in the above mentioned study, a more detailed investigation was suggested.

EXPERIMENTAL METHODS AND PROCEDURES

In 1968, at seven sites where corn followed corn, the presence or absence of rootworm insecticide was included as another applied variable, in addition to the applied fertilizer treatments. A split plot design was used for these experiments with the fertilizer treatments as whole plots and insecticide treatment as subplots. Thus, each fertilizer treatment plot was split into two, half with and half without insecticide. The fertilizer treatments were identical to those employed at all other sites in 1967 and 1968 and were randomly allocated to the 25 whole plots. The insecticide used was Buxten at the rate of one pound of effective material per acre applied over the row at planting time.

Each whole plot consisted of eight rows, thirty feet long. Thus, each subplot was four rows by thirty feet. Twenty feet from the middle two rows of each subplot were included in the harvest area.

Field procedures for this experiment were identical to those outlined in Part I, with the addition of root rating procedures. At maturity, five plants were randomly selected from each subplot for rating. A seven inch cube of soil containing the crown of corn roots was removed from the ground. The soil was shaken and washed off with water under pressure. A damage rating and a size (recovery) rating were assigned to each clump of roots. The interpretation of these ratings were listed in Table 4. For data analyses, the average rating of the five plants from each subplot was used.

Of the seven sites initiated, the results from only six are reported. One site was so severely damaged by drouth that grain yields were near zero on many plots and generally less than 20 bushels per acre. To avoid the effect of these extreme results on derived relationships between grain yield and other factors, data from this experiment were not analyzed.

Table 33 lists the ranges of many of the pertinent factors of these Rootworm-Fertility experiments. Complete data are listed in Appendix C, Table 50. The ranges in soil N, soil K and soil pH were not wide; all sites were "high" in soil K, "low" in soil N and slightly acid. No "low" soil P sites were available for this study. However, a range from "low-medium" to "high" was obtained. Most of the sites were under considerable moisture stress throughout the season which resulted in lower than average grain yields and reduced response to applied fertility.

Table 33. Ranges in values of variables measured at six sites in the rootworm-fertility experiments

Variable	Range
Soil N, n	52 - 75 pp2m
Soil K, k	230-420 pp2m
Soil P, p	24 - 83 pp2m
Soil pH, a	6.0 - 6.5
Subsoil N (6-12"), n_s	24 - 36 pp2m
Subsoil K (6-12"), k_s	90 - 210 pp2m
Subsoil P (12-24"), P_s	7 - 26 pp2m
Subsoil pH (6-12"), a_s	6.0 - 6.8
Past cropping, R	2.7 - 4.7
Planting date, T	May 1 - May 9
Soil yield potential, C	93 - 109 bu/A
Plant population, S	16.3 - 21.6 thousand/A
Stress days (Dale), D_1	21 - 56
Nonstress index (Mod. Dale), D_2	34 - 57
Relative Ps (Shaw-Laing), D_3	7 - 47
Average site yield, Y_A	50 - 96 bu/A
Check plot yield, Y_o	54 - 90 bu/A
Root size, treated, RS_T	3.4 - 3.7
Root size, nontreated, RS_N	2.0 - 3.3
Root damage, treated, RD_T	1.8 - 2.3
Root damage, nontreated, RD_N	2.3 - 3.9

RESULTS AND DISCUSSION

Three dependent variables were studied. These were grain yield, root size and root damage. Root damage reflects the amount of feeding by rootworm larvae; root size (or recovery) reflects the growth, or regrowth after damage; if any has occurred. The relative effects of fertility, insecticide, and any interactions between fertility and insecticide, on the variability in each of the three dependent variables were determined. These effects were determined for each site individually and for all sites combined.

The analyses of variance for each individual site are listed in Appendix C, Tables 47, 48, 49. The analyses of variance for the combined sites are listed in Tables 34, 35 and 36, for yield, root size and root damage, respectively. Inspection of the AOV's at each site reveals that fertility and insecticide treatments both affected yield significantly. As would be expected, applied nitrogen significantly increased yields at all sites, and this effect generally carried through to the high rates. Phosphorus fertilizer increased yield at 5 of the six sites but at a decreasing rate as P rates increased. These increases were obtained despite the fact all sites contained 25 pp2m or more available P in the top six inches of soil, and four sites had 35 pp2m or more. These responses may have been due to the top six inches being dry.

Table 34. Analysis of variance of grain yields from split plot design of rootworm-fertility experiments for all sites combined

Source of variation[a]	df	Sums of squares	Mean square	F-ratio
Whole plots	24	11863.71		
Trts	9	8288.28	920.92	3.86**
+N	1	6538.76	6538.76	27.4***
$+N^2$	1	377.56	377.56	1.58+
+P	1	119.74	119.74	< 1
$-P^2$	1	38.57	38.57	< 1
-K	1	548.69	548.69	2.30++
$-K^2$	1	6.07	6.07	< 1
+NP	1	193.60	193.60	< 1
-NK	1	520.14	520.14	2.18++
+PK	1	4.26	4.26	< 1
Error	15	3575.43	238.36	
Subplots	275	126267.22		
+I	1	720.49	720.49	1.54+
Trts X I	9	1669.83	185.54	< 1
-NI	1	55.53	55.53	< 1
$-N^2I$	1	407.40	407.40	< 1
+PI	1	331.52	331.52	< 1
$+P^2I$	1	.48	.48	< 1
+KI	1	351.39	351.39	< 1
$+K^2I$	1	6.46	6.46	< 1
-NPI	1	457.91	457.91	< 1
+NKI	1	30.40	30.40	< 1
-PKI	1	28.72	28.72	< 1
Error(b)	265	123876.91	467.46	

[a]Preceding signs indicate direction of effect.

Table 35. Analysis of variance of root size (recovery) ratings of rootworm-fertility experiments for all sites combined

Source of variation[a]	df	Sums of squares	Mean square	F-ratio
Whole plots	24	5.7600		
Trts	9	2.3048	0.2561	1.11
+N	1	0.2670	0.2670	1.16
$+N^2$	1	0.7272	0.7272	3.16+++
+P	1	0.2009	0.2009	< 1
$-P^2$	1	0.4790	0.4790	2.08++
+K	1	0.0891	0.0891	< 1
$+K^2$	1	0.0381	0.0381	< 1
-NP	1	0.0416	0.0416	< 1
-NK	1	0.1534	0.1534	< 1
-PK	1	0.5210	0.5210	2.26++
Error(a)	15	3.4552	0.2303	
Subplots	275	147.2092		
+I	1	38.9978	38.9978	110.***
Trts X I	9	13.8862	1.5429	4.34***
-NI	1	0.8939	0.8939	2.51++
$+N^2I$	1	0.0016	0.0016	< 1
-PI	1	0.0002	0.0002	< 1
$+P^2I$	1	10.3670	10.3670	29.1***
-KI	1	0.0688	0.0688	< 1
$-K^2I$	1	0.0264	0.0264	< 1
+NPI	1	0.1111	0.1111	< 1
+NKI	1	0.0159	0.0159	<11
-PKI	1	2.4013	2.4013	6.75**
Error(b)	265	94.3166	0.3559	

[a]Preceding signs indicate direction of effect.

Table 36. Analysis of variance of root damage ratings of rootworm-fertility experiments of all sites combined

Source of variation	df	Sums of squares	Mean square	F-ratio
Whole plots	24	5.1533		
Trts	9	2.5081	0.2782	1.58+
-N	1	0.0227	0.0227	< 1
$-N^2$	1	0.3039	0.3039	1.72+
-P	1	0.4767	0.4767	2.71++
$+P^2$	1	0.6334	0.6344	3.60++
+K	1	0.4506	0.4506	2.56++
$+K^2$	1	0.6347	0.6347	3.61+++
+NP	1	0.0895	0.0895	< 1
-NK	1	0.0076	0.0076	< 1
-PK	1	0.0055	0.0055	< 1
Error(a)	15	2.6452	0.1763	
Subplots	275	198.9892		
-I	1	105.2072	105.2072	297.***
Trts X I	9	7.3802	0.8200	2.32*
+NI	1	0.0225	0.0225	< 1
$+N^2I$	1	0.6193	0.6193	1.75++
+PI	1	0.6982	0.6982	1.97++
$-P^2I$	1	3.7723	3.7723	10.7***
-KI	1	1.5089	1.5089	4.26*
$-K^2I$	1	0.2703	0.2703	< 1
-NPI	1	0.0563	0.0563	< 1
+NKI	1	0.4279	0.4279	1.21+
-PKI	1	0.0045	0.0045	< 1
Error(b)	265	93.7640	0.3538	

[a]Preceding signs indicate direction of effect.

Under these conditions, absorption of water and nutrients by the roots must take place at greater depths, where available soil phosphorous was less. The yield response to applied K was negative at all six sites, significantly negative at four of these sites. The negative effect increased as applied K rates increased. The sites which were included in this study all contained more than 200 pp2m exchangeable K in the top six inches of soil. The applied fertilizer interactions of NP, NK and PK were generally nonsignificant at all sites.

Upon combining the data from all sites, similar but not identical effects resulted. The increase in yield due to applied N was highly significant and increased as N rates increased. The effect of applied P was nonsignificant. The trend was toward an increase at low rates, but this increase was less as P rates increased. The effect of applied K was significant and negative. The quadratic term, indicating response patterns as rates increased, was nonsignificant. A positive NP interaction, indicating greater response to either N or P as the other was increased, was present but not statistically significant. The NK interaction was significant and negative, This indicates that either the increase due to N was less at higher rates of K or the decrease due to K was less at higher rates of N. The PK interaction was essentially nonexistent.

The plots which received insecticide outyielded those which did not receive insecticide at five of the six sites, but at only three of the sites were the increases statistically significant. The increases ranged from 2 bu/A to 10 bu/A averaged across all 25 plots. The one site at which a decrease of 6 bu/A was measured was very drouthy (56 of 63 days were classed as stress days; relative photosynthesis rating was less than 7) and had an average population of nearly 22,000 plants per acre. Any interactions between applied fertility and insecticide treated plots were not apparent, nor were trends generally consistent. At one site a significant and negative KI (I denoting presence of insecticide) interaction was observed. That is, K decreased yield more on insecticide treated plots. Analysis of variance of all sites combined indicated a positive and significant effect due to insecticide, an average of 4 bu/A over all plots at all sites. All fertilizer by insecticide interactions were nonsignificant, indicating the same response patterns on both treated and untreated plots.

Analyses of variance with root size, or recovery ratings as the dependent variable indicated that the presence or absence of insecticide largely determined the root size. This effect was not true at one of the sites, where the effect was only slightly positive. The effect of applied fertilizer on root size was not consistent from site to site. However, applied N did increase root size at five sites, three of them significantly. Positive effects of N were most obvious at higher rates of N. Combined analysis showed a nonsignificant positive linear and significant positive quadratic effect. The effect of applied P was inconsistent as four sites showed a significant negative effect and the other two significant positive effects. Combined AOV showed a nonsignificant linear effect but a significant negative quadratic effect, indicating decreased root size at high rates of P. The effect of K on root size was inconsistent and generally nonsignificant. The same was true for the fertilizer interactions, except for a negative PK interaction which indicates the probable decreased root size by P was greater at high rates of K.

Fertilizer X insecticide interactions were inconsistent. However, in the pooled AOV, the interaction of fertilizer by insecticide was highly significant. The individual interaction which contributed most to this was a positive P^2I term, which was associated with a nearly nonexistent linear PI term. This indicates that decreased root size with increasing rates of P was more significant on the untreated plots. Also, making a significant contribution toward the significant fertilizer by insecticide interaction was a negative PKI interaction, which indicates that the detrimental effects of increasing P and K together was less on the nontreated plots. The significant and negative NI term indicates more increased root size due to N on the nontreated plots. That is, on the plots which received no insecticide, applied N compensated.

Root damage due to rootworm activity was prevented almost completely through the use of insecticide. The average damage ratings at all sites were 3.2 for the untreated plots and 2.0 for the plots which received insecticide. The ranges of site averages were 3.9 to 2.3 for untreated and 1.8 to 2.3 for treated plots. Correspondingly the average recovery or size ratings were 3.5 and 2.7 for treated and nontreated plots, respectively. The ranges in site averages were 3.7 to 3.4 for treated and 3.3 to 2.0 for nontreated. The simple correlation between root damage and root size was -0.77 for all plots at all sites. (The complete correlation matrix is listed in Appendix C, Table 46.) The effects of fertility and insecticide were similar on damage and size, but generally in opposite directions. However, some differences in the effects were present. The presence or absence of insecticide was more responsible for controlling damage than size. The effect of N was not as great in reducing damage as it was in promoting root size or regrowth after damage. Phosphorus decreased root damage at the lower rates but at a decreasing rate, so that at high P rates increased damage resulted. Potassium significantly increased damage at an increasing rate as levels of K increased. The fertilizer interactions were generally inconsistent and nonsignificant with respect to their effects on root damage.

Fertilizer by insecticide interactions were generally not consistent but frequently significant on a site basis. The pooled AOV reveals a significant fertilizer by insecticide interaction with several individual interactions contributing. Applied N at high rates decreased damage more on the nontreated plots. Applied P at the lower rates also decreased damage more on the nontreated plots. However, at higher rates, the effect reverses, and this effect is much greater than the effect at lower rates. Applied K appeared to promote more damage on the nontreated plots.

Because of the limited scope of this experiment, any conclusions which are drawn must be done so with great caution. There appears to be little question that the application of rootworm insecticide on corn following corn is an economically sound, if not essential, practice. In this experiment, the response to fertilizer was essentially the same on the insecticide treated plots as on the nontreated plots with respect to grain yield. Applied N appeared to promote root size and prevent some damage. On the contrary, applied P and K, particularly at high rates, enhanced root damage which frequently resulted in reduced root size. Fertilizer effects on root damage and size were not the same on both treated and nontreated plots, but these differences did not manifest themselves significantly in grain yields.

The effect of indigenous fertility upon grain yield, root size and root damage, was also investigated. Surface soil N, P, and K and pH were considered as the independent variables representing indigenous fertility. These four factors were highly correlated, however, at each site and for the entire experiment. Thus, interpretations of independent effects are not possible in the strict sense; only the effect of each variable after fitting the remainder of the variables are available. That is, the magnitude and direction of effect of each soil fertility characteristic is not independent from the effects of the other soil fertility factors.

Table 37 lists analyses of variance for the combined data from six experiments in which the only sources of variation considered were the four fertility factors, insecticide treatment and the interactions between each fertility factor and insecticide. All of the remaining variation in each of the three dependent variables was considered as error. The AOV in which grain yield was the dependent variable reveals that soil P, soil K and soil pH had highly significant effects on grain yield, soil P in a positive direction and soil K

Table 37. Analyses of variance showing effects of indigenous soil fertility, insecticide treatment and their interactions on grain yield, root size and root damage

Source of variation[a]	d.f.	Mean square	F-ratio
	A. Yield		
-n	1	80.46	< 1
+p	1	5399.10	14.1***
-k	1	12041.77	31.4***
-a	1	7225.98	18.8***
+I	1	916.92	2.39++
+nI	1	74.29	< 1
-pI	1	16.36	< 1
-kI	1	115.59	< 1
-aI	1	945.89	2.46++
Error	290	384.84	
	B. Root size		
-n	1	30.151	91.1***
+p	1	0.219	< 1
+k	1	5.268	15.9***
+a	1	0.060	< 1
-I	1	0.228	< 1
+nI	1	17.644	53.3***
+pI	1	0.064	< 1
-kI	1	2.984	9.02***
+aI	1	0.274	< 1
Error	290	0.331	
	C. Root damage		
+n	1	49.999	172.***
+p	1	12.097	41.6***
-k	1	32.343	111.***
-a	1	1.300	4.47*
-I	1	0.581	2.00++
-nI	1	15.276	52.5***
+pI	1	4.505	15.5***
+kI	1	3.469	11.9***
-aI	1	0.201	< 1
Error	290	0.291	

[a]Preceding signs indicate direction of effect.

and soil pH in a negative direction. The effect of insecticide was significant at the 20% level. This effect is independent from soil effects. As was the case with applied fertility, the interactions between indigenous fertility and insecticide were not significant, which indicates that the effect of the levels of soil nutrients and soil pH were the same on treated as nontreated plots. The single exception was soil pH. Yield was not decreased as much on the nontreated plots as soil pH increased.

The effect of insecticide on root size and root damage was large. The simple correlations between insecticide treatment and size was 0.57, and the correlation between insecticide treatment and damage was -0.74. However, the influences of insecticide on size and damage varied greatly with soil test levels. This is indicated in Table 37B and 37C. These analyses of variance reveal that insecticide treatment, by itself, was not significant in explaining root size variability and significant at only the 20% level of probability in explaining root damage variability when considered simultaneously with soil test values. However, in contrast to the analysis of variance for grain yield, the interactions among the various soil test levels and insecticide treatment were generally highly significant.

Root size (or recovery) was significantly influenced by soil N and soil K. Furthermore, the effects of soil N and soil K were not the same on treated as nontreated plots. Root size was less at sites where soil N was higher. An interpretation of this could be that roots growing in soil high in nitrogen did not need to encompass as large of area in order to obtain nitrogen. However, the positive soil N by insecticide interaction indicates that either the adverse effect of soil N on root size was less on treated plots or that root size actually increased with increasing amounts of soil N in the treated plots. Soil K apparently affected root size oppositely from soil N, as the main effect was positive and its interaction with insecticide was negative, the latter indicating more promotion of root recovery or size on the nontreated plots. That is, an apparent compensation for the lack of insecticide by soil K in enhancing root size was present. Soil P level did not appear to be associated with root size.

The effect of soil test levels appeared to be even more closely associated with root damage than root size. In addition to soil N and soil K, soil P and soil pH also appeared to influence root damage. The influence of soil pH was less than the other three and its effect of decreasing damage as soil pH increased did not vary between the treated and nontreated plots. The direction of effects associated with the other three soil tests were, as follows: after fitting the other eight terms, root damage increased with increasing amounts of soil N and more in the absence of insecticide; root damage increased with increasing soil P but less in the absence of insecticide (or, damage may have been decreased on the treated plots as soil P increases); root damage decreased with increasing soil K and more in the absence of insecticide.

Despite the apparent relationships which existed between indigenous soil fertility and root size and damage, very little additional variation in root ratings was explained by the soil test levels beyond the variation explained by insecticide alone. For example, the simple correlation (r) between root size and insecticide treatment was 0.57, while the multiple correlation (R) between root size and all of the effects listed in Table 37 was only 0.61. Similarly, the simple correlation (r) between root damage and insecticide treatment was -0.74, while the multiple correlation between root damage and the effects of soil test values, insecticide treatment and soil test by insecticide interactions, was only -0.77. Thus, the interpretative value of the analyses of variance listed in Table 37B and 37C can be seriously questioned.

Because of the narrow ranges in many of the indigenous soil variables, because many of the effects appear to be contrary to the effects of applied fertility variables, and because the indigenous soil variables were highly correlated, any conclusions concerning the effect of indigenous soil fertility on root damage by rootworms and subsequent growth or regrowth would be drawn with reluctance. The hypotheses that rootworm activity, and consequently root damage, is different in soils with different fertility levels has not been disproved by these experiments because significant differences were measured with both applied and indigenous fertility. Sufficient evidence may have been provided to merit further field investigations over a broader range of soil, management and climatic conditions, as well as a more complete range in soil test levels.

SUMMARY AND CONCLUSIONS

The specific objectives of this research project were, first, to quantitatively evaluate the relationships among soil, plant, climatic and management factors as they influenced N, P and K fertilizer response by corn on the Marshall and Monona soils of Western Iowa; second, to evaluate the relationships between leaf nutrient concentrations and environmental factors and between grain yield and leaf concentrations; and, third to investigate the possibility of a corn rootworm - soil fertility interaction. A general objective was to determine the experimental methods and procedures which were necessary to fulfill the specific objectives.

With regard to the general objective it is concluded that field experimentation, which is conducted in an almost completely uncontrolled environment, requires quantitative evaluation of all controlled and uncontrolled variables which have an influence on yield, or any other dependent variable under study. This is necessary because of the many interactions between controlled and uncontrolled variables and among the uncontrolled variables.

Experimental sites were selected for this investigation to provide wide ranges in the uncontrolled variables which were to be studied. These variables included soil and subsoil N, P, K and pH, past cropping system, planting date, soil yielding potential, plant population and soil moisture. Variability in some factors was eliminated or restricted by limiting the experiments to Marshall and Monona soils in Western Iowa. The applied variables were N, P and K fertilizers at rates from 0-200 lbs/A, 0-60 lbs/A and 0-120 lbs/A, respectively.

It was found that replication of all applied treatments at each site was not necessary. Because of the variation in soil, plant and, even, climatic factors within a given site, true replication is impossible. Furthermore, no particular level of treatment is of great importance, by itself. Rather, it is the response function from some base level to some maximum level which is of importance. Thus, more points at different levels along the response surface are more useful than repetition of any one level.

A soil sampling procedure was followed which permitted the determination of true soil variability within a site with respect to laboratory and sampling errors, for the various soil tests. It was concluded that many sites, though appearing to be uniform, actually varied considerably with respect to one or more of the soil tests. Thus, the need for sampling and characterization of each individual plot was further substantiated.

Two weather indices, and a modification of each, were evaluated. A wide range of climatic conditions was present during the two year study. Shaw's modification of Laing's relative photosynthesis index was chosen on the bases of highest correlation with yield ($r = 0.68$) and a wide range in values, 7 to 57 from a possible 0 to 63.

A quadratic polynomial containing applied fertilizer linear, quadratic and interaction terms was fitted to data from each of 23 sites using multiple regression techniques and an IBM-360 computer. In some cases, covariates for stand and barrenness were used. This provided a characterization of response at each level of the uncontrolled factors. An examination of the variability in regression coefficients provided a method to determine which applied fertilizer terms varied as uncontrolled factors varied. Regression models with the fertilizer regression coefficients from each site as dependent variables and the uncontrolled factors as independent variables were used to determine which interactions to enter into a final yield prediction equation. A modified stepwise multiple regression technique was used to build the final equation. Yield was used as the dependent variable in successive models which included each of four major types of factors - applied fertility, indigenous fertility, management, and climate. Using applied fertility as the base, the other groups of factors were added consecutively. Finally, interactions among the four groups of factors were added.

Characterization of response at each site revealed that most sites responded positively to applied N, response to applied P was highly correlated with soil P level; and, response to applied K was not significant at most sites, but was generally negative on Marshall soils and positive on Monona soils. Fertilizer interaction terms were inconsistent and not generally significant.

Regression models fitted to data from all plots revealed that the fertilizer quadratic equation was unsatisfactory in explaining variability in observed yields, as an R^2 of only 0.04 resulted. Indigenous fertility explained 16% of the variability, management variables explained 19%, and weather alone accounted for 46% of the variability in observed yields.

A final yield equation was derived which contained 40 terms with an R^2 of approximately 0.80.

Response to applied N was influenced positively by increasing amounts of soil moisture, distance from meadow, and plant population. Response to applied N decreased with increasing soil yield potential and soil test N.

Response to applied P increased slightly as soil moisture increased but not to the extent that response to N increased. Response to applied P decreased as surface and subsoil P increased. In general, response to P was not influenced as greatly by environmental factors as was response to N.

The next response to applied K was negative but not statistically significant. Response was more positive on first year corn than continuous corn and more positive where soil N was higher. However, soil yield potential, past cropping and soil test N were somewhat confounded in this experiment.

Yield response to increased plant population was much greater with increasing soil moisture, and/or vice versa.

Leaf nutrient content was generally a function of the same variables that determined yield. However, applied and indigenous fertility influenced leaf content more than they did yield, while climatic and management factors were less influential.

Leaf nutrient concentrations were not related to grain yields, however, unless several management and climatic factors were considered simultaneously. The leaf concentrations for N and P associated with optimum yields were influenced by past cropping, plant population, soil yielding potential and soil moisture. At the average experimental values for these variables in this study, 95% of the maximum predicted yield could be attained with leaf N and P concentrations of 2.9% and 0.28%, respectively.

Conclusions from the rootworm - fertility experiments were not obvious. However, indications of increased root damage at high levels of either applied or indigenous fertility were measured.

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ACKNOWLEDGMENTS

The author is indebted to Dr. John Hanway for his continuous advice, support, encouragement and helpful criticisms throughout the period in which this research project was accomplished.

The author wishes to thank the many members of the Agronomy Department staff and those of the Statistics and Computer Science Departments, who gave of their time to provide advice and assistance with various phases of this research project.

To my wife, son, and parents, whose efforts, patience and encouragement made the completion of this degree possible, the author is especially grateful.

APPENDIX A. INFORMATION CONCERNING ALL SITES

Table 38. Cooperators and location of experimental sites

Site number	Name	Address	County	Location of site	Soil type
		A. 1967			
02	John Bell	Rt 1, Atlantic	Cass	SW 1/4, Sec 1, Twp Grove	Marshall
03	Marion Johnson	Rt 2, Lewis	Cass	NE 1/4, Sec 2, Twp Cass	Marshall
04	Bob Kennedy	Lewis	Cass	SE 1/4, Sec 13, Twp Cass	Marshall
05	Ken Schuler	Rt 2, Villisca	Cass	SE 1/4, Sec 26, Twp Noble	Marshall
06	John Cassens	Schleswig	Crawford	SE 1/4, Sec 1, Twp Morgan	Monona
08[a]	Walt Ketelson	Rt 2, Charter Oak	Crawford	SE 1/4, Sec 3, Twp Willow	Monona
09	Robert Seda	Dunlap	Crawford	SE 1/4, Sec 30, Twp Boyer	Monona
11	Harry Musfeldt	Rt 1, Manning	Crawford	SE 1/4, Sec 14, Twp Iowa	Marshall
12	Clifford Lundegard	Logan	Harrison	SW 1/4, Sec 30, Twp Jefferson	Monona
14[a]	Ken Adler	Rt 2, Anthon	Woodbury	NW 1/4, Sec 25, Twp Wolf Creek	Monona
15[a]	Merril Friedrich	Rt 2, Anthon	Woodbury	SW 1/4, Sec 20, Twp Wolf Creek	Ida
16[a]	Laverne Roggatz	Rt 1, Oto	Woodbury	SE 1/4, Sec 22, Twp Grant	Monona-Ida
17	Don Albers	Danbury	Woodbury	NW 1/4, Sec 4, Twp Morgan	Monona-Ida

[a]These sites were not included in data analyses for reasons explained in text.

Table 38. (Continued)

Site number	Name	Address	County	Location of site	Soil type
		B. 1968			
18[a]	Dale Westphalen	Rt 3, Atlantic	Cass	SW 1/4, Sec 2, Twp Pymosa	Marshall
20	John Bell	Rt 1, Atlantic	Cass	NE 1/4, Sec 12, Twp Grove	Marshall
21	Marion Johnson	Rt 2, Lewis	Cass	NE 1/4, Sec 2, Twp Cass	Marshall
22	Jim Hunt Bob Kennedy	Rt 2, Atlantic Lewis	Cass	SE 1/4, Sec 13, Twp Cass	Marshall
23	Ralph Riggs	Rt 1, Atlantic	Cass	NE 1/4, Sec 14, Twp Bear Brove	Marshall Var.
24	Ken Schuler	Rt 2, Villisca	Cass	SE 1/4, Sec 26, Twp Noble	Marshall
26	Elmer Reimer	Schleswig	Crawford	SW 1/4, Sec 20, Twp Morgan	Monona
27	Richard Clark	Rt 2, Dow City	Crawford	NE 1/4, Sec 11, Twp Boyer	Monona
29	Willis Ahrenholtz	Rt 4, Denison	Crawford	NW 1/4, Sec 1, Twp Washington	Marshall
31	Russell Lefeber	Rt 2, Dunlap	Harrison	SW 1/4, Sec 13, Twp Douglas	Monona
32	Guy Burkholder	Woodbine	Harrison	SW 1/4, Sec 30, Twp Douglas	Monona
33	Glenn Boustead	Rt 2, Woodbine	Harrison	SE 1/4, Sec 1 Twp Jefferson	Monona
36	Everett Rasmussen	Lawton	Woodbury	SW 1/4, Sec 9 Twp Floyd	Monona

Table 38. (Continued)

Site number	Name	Address	County	Location of site	Soil type
37[a]	Ken Bruene	Cushing	Woodbury	NE 1/4, Sec 15, Twp Rock	Monona
38	Don Albers	Danbury	Woodbury	NW 1/4, Sec 4, Twp Morgan	Monona
39	ISU Alumni Foundation (Davies Farm)	Morrill Hall (Malvern)	Mills	SE 1/4, Sec 27, Twp Center	Marshall
40	Cliff Lunde-gard	Logan	Harrison	SW 1/4, Sec 20, Twp Jefferson	Monona

Table 39. Soil test values for profile samples at each experimental site

Depth inches	NH_4 pp2m	NO_3 pp2m	P pp2m	K pp2m	Soil pH	Depth inches	NH_4 pp2m	NO_3 pp2m	P pp2m	K pp2m	Soil pH
		Site 02						Site 03			
0-6	44	67	41	316	6.4	0-6	56	71	31	341	6.4
6-12	17	56	19	178	6.8	6-12	20	45	21	186	6.4
12-24	11	19	16	99	6.8	12-24	9	43	18	144	6.5
24-36	8	11	14	60	6.9	24-36	10	25	32	115	6.6
36-48	1	10	18	53	6.9	36-48	8	18	62	82	6.6
		Site 04						Site 05			
0-6	42	58	42	324	6.0	0-6	36	60	30	277	7.2
6-12	13	38	17	182	6.0	6-12	14	40	17	140	6.8
12-24	20	27	9	117	6.3	12-24	10	22	14	102	6.9
24-36	8	12	22	75	6.4	24-36	6	12	30	73	6.9
36-48	0	10	40	65	6.5	36-48	6	9	30	60	7.0
		Site 06						Site 08[a]			
0-6	42	66	15	192	6.2	0-6	61	62	7	213	6.6
6-12	11	18	6	72	6.9	6-12	14	10	6	72	7.0
12-24	9	10	6	59	7.2	12-24	8	11	8	52	7.3
24-36	7	8	5	58	7.7	24-36	2	8	10	50	7.3
36-48	8	9	4	66	7.9	36-48	2	10	14	56	7.2
		Site 09						Site 11			
0-6	54	56	11	188	6.7	0-6	63	92	14	202	6.4
6-12	10	29	6	76	6.7	6-12	21	28	10	80	6.5
12-24	6	16	6	48	7.0	12-24	8	17	18	68	6.6
24-36	1	9	12	42	7.0	24-36	5	14	22	49	6.7
36-48	5	8	22	40	7.1	36-48	6	16	22	61	6.8

[a]Sites not included in data analyses.

Table 39. (Continued)

Depth inches	NH_4 pp2m	NO_3 pp2m	P pp2m	K pp2m	Soil pH	Depth inches	NH_4 pp2m	NO_3 pp2m	P pp2m	K pp2m	Soil pH
		Site 12						Site 14[a]			
0-6	56	59	20	227	6.5	0-6	83	80	35	453	6.5
6-12	10	42	7	98	6.5	6-12	16	35	12	152	6.7
12-14	6	15	5	56	6.9	12-24	10	15	8	70	6.8
24-36	4	10	5	48	7.0	24-36	6	9	10	66	7.0
36-48	4	10	8	49	7.2	36-48	4	9	19	59	7.1
		Site 15[a]						Site 17			
0-6	52	59	8	146	7.8	0-6	51	72	25	168	7.1
6-12	8	26	4	64	8.0	6-12	8	31	6	70	7.8
12-24	10	21	2	59	8.1	12-24	8	10	5	46	7.8
24-36	2	15	2	55	8.2	24-36	4	7	8	41	7.8
36-48	5	14	1	54	8.2	36-48	4	8	10	45	7.9
		Site 20						Site 21			
0-6	40	61	38	280	6.6	0-6	44	54	38	320	6.1
6-12	12	30	16	137	6.4	6-12	28	36	24	212	6.0
12-24	9	25	12	78	6.3	12-24	12	28	18	126	6.0
24-36	2	19	28	65	6.5	24-36	10	22	34	89	6.0
36-48	3	14	34	54	6.5	36-48	8	13	42	60	6.3
48-60	11	14	35	50	6.6	48-60	10	14	42	63	6.5
		Site 22						Site 23			
0-6	65	76	84	420	5.9	0-6	58	78	10	260	6.1
6-12	16	30	26	125	6.4	6-12	18	22	8	90	6.3
12-24	8	17	26	80	6.7	12-24	7	16	6	61	6.5
24-36	4	14	32	68	6.8	24-36	2	9	8	48	6.8
36-48	1	8	26	64	7.3	36-48	7	9	6	65	7.0
48-60	4	16	20	56	7.7	48-60	3	8	7	72	7.1

Table 39. (Continued)

Depth inches	NH_4 pp2m	NO_3 pp2m	P pp2m	K pp2m	Soil pH	Depth inches	NH_4 pp2m	NO_3 pp2m	P pp2m	K pp2m	Soil pH
		Site 24a						Site 26			
0-6	59	70	67	478	6.7	0-6	41	58	20	200	7.3
6-12	17	40	40	281	6.8	6-12	16	26	6	78	7.3
12-24	9	31	32	175	6.6	12-24	6	23	8	54	7.3
24-36	8	20	56	162	6.2	24-36	4	20	10	44	7.3
36-48	3	14	74	89	6.0	36-48	1	12	14	44	7.3
48-60	11	20	61	70	6.0	48-60	11	16	18	58	7.4
		Site 27						Site 29			
0-6	52	62	28	220	6.0	0-6	52	75	52	410	5.9
6-12	18	29	12	94	6.4	6-12	11	26	16	135	6.2
12-24	9	22	13	54	6.9	12-24	5	21	17	88	6.6
24-36	4	12	24	45	7.0	24-36	5	18	18	60	6.8
36-48	2	16	28	40	7.0	36-48	1	14	23	62	6.9
48-60	2	13	28	52	7.0	48-60	6	10	27	64	7.0
		Site 31						Site 32			
0-6	49	62	26	350	6.1	0-6	46	57	20	190	6.9
6-12	19	32	14	223	6.2	6-12	17	22	10	107	6.8
12-24	10	22	10	91	6.4	12-24	16	18	10	70	6.7
24-36	7	16	16	75	6.5	24-36	9	13	10	51	6.8
36-48	1	14	24	64	6.7	36-48	2	11	16	49	7.1
48-60	3	13	32	62	6.8	48-60	2	13	22	87	7.1
		Site 33						Site 40			
0-6	56	52	20	190	6.8	0-6	50	54	36	260	6.5
6-12	17	26	8	89	6.7	6-12	9	24	12	92	6.8
12-24	6	14	8	54	7.0	12-24	6	18	6	58	7.0
24-36	9	12	10	56	7.3	24-36	6	16	7	49	7.2
36-48	1	10	16	55	7.6	36-48	4	14	9	54	7.4
48-60	3	9	16	74	8.0	48-60	2	10	12	52	7.7

Table 39. (Continued)

Depth inches	NH_4 pp2m	NO_3 pp2m	P pp2m	K pp2m	Soil pH	Depth inches	NH_4 pp2m	NO_3 pp2m	P pp2m	K pp2m	Soil pH
		Site 36						Site 37			
0-6	96	60	8	220	6.9	0-6	56	83	16	200	6.1
6-12	28	26	5	117	7.1	6-12	20	36	10	78	6.4
12-24	11	17	6	67	7.3	12-24	6	25	12	52	6.6
24-36	6	13	16	56	7.4	24-36	7	13	14	36	6.9
36-48	8	13	26	40	7.4	36-48	2	17	22	39	7.0
48-60	4	13	28	54	7.2	48-60	1	13	21	44	7.4
		Site 38						Site 39			
0-6	56	56	24	225	6.4	0-6	40	52	26	240	5.9
6-12	23	29	10	89	6.6	6-12	28	40	12	212	5.8
12-24	12	16	14	59	6.7	12-24	12	20	7	125	6.2
24-36	6	12	23	49	6.8	24-36	9	7	12	81	6.6
36-48	2	11	22	49	6.9	36-48	8	8	28	72	6.8
48-60	2	9	28	54	7.0	48-60	4	5	35	67	7.0
		Marshall Sites[b]						Monona Sites[c]			
0-6	49	67	42	328	6.3	0-6	57	63	18	216	6.6
6-12	17	37	20	172	6.4	6-12	15	27	8	95	6.8
12-24	10	27	17	10	6.5	12-24	9	17	8	58	7.0
24-36	7	17	27	82	6.6	24-36	5	12	11	50	7.2
36-48	4	13	36	65	6.7	36-48	4	11	16	51	7.2
48-60	8	15	37	61	6.8	48-60	3	12	21	61	7.3

[b]Average of Sites 2,3,4,5,11,20,21,22,24,29,39.

[c]Average of Sites 6,8,9,12,14,17,23,26,27,31,32,33,36,37,38,40.

Table 40. Weekly totals of calculation of four stress indices at each experimental site

Site no.	A. Number of stress days[a]												
	6B	5B	4B	3B	2B	1B	1A	2A	3A	4A	5A	Σ 6B-5A	Σ 6B-3A
1967													
02	0	0	0	2	5	3	3	6	6	6	6	37	25
03	0	0	0	0	2	5	1	1	5	5	6	25	14
04	0	0	0	3	5	1	3	5	6	7	4	34	23
05	0	0	0	3	2	0	2	5	5	3	2	22	17
06	0	0	0	1	3	3	1	4	2	4	2	20	14
09	0	0	0	0	0	2	1	4	5	6	5	23	12
11	0	0	1	3	5	5	6	6	7	7	7	47	33
12	0	0	0	3	2	6	6	7	7	7	7	45	31
17	0	0	1	1	4	6	5	6	6	7	6	42	29
1968													
20	4	4	7	7	7	7	7	7	6	5	3	64	56
21	4	4	7	7	7	5	3	7	7	7	5	63	51
22	3	3	7	7	7	5	4	4	7	6	4	57	47
23	4	4	7	7	7	7	7	7	7	7	5	69	57
26	2	0	1	6	7	6	6	4	7	7	1	47	39
27	2	2	3	5	7	6	7	6	7	5	4	54	45
29	4	0	0	6	6	6	7	6	7	7	2	51	42
31	0	2	0	3	6	5	5	4	4	5	6	40	29
32	2	0	0	6	6	3	3	3	4	6	1	34	27
33	3	0	1	6	7	4	4	4	7	7	1	44	36
36	5	1	1	3	5	6	7	6	7	7	6	54	41
38	2	0	0	2	5	5	7	4	7	6	3	41	32
39	2	4	7	6	6	6	5	3	2	0	1	42	41
40	0	2	0	3	6	5	2	2	1	3	6	30	21

[a]B = before silking, A = after silking.

Table 40. (Continued)

Site no.	B. Nonstress index - Quantification of stress ratio												
	6B	5B	4B	3B	2B	1B	1A	2A	3A	4A	5A	Σ 6B-5A	Σ 6B-3A
1967													
02	7.0	7.0	7.0	6.8	5.5	6.5	6.5	5.4	5.4	4.5	6.0	67.6	57.2
03	7.0	7.0	7.0	7.0	6.9	5.8	6.8	6.7	5.8	6.0	5.1	71.1	59.9
04	7.0	7.0	7.0	6.2	6.0	6.9	6.4	5.4	5.2	5.7	6.0	68.8	57.0
05	7.0	7.0	7.0	6.5	6.5	7.0	6.9	5.8	5.9	6.2	6.3	72.1	59.6
06	7.0	7.0	7.0	6.9	6.7	6.5	7.0	6.3	6.7	5.9	6.8	73.8	61.0
09	7.0	7.0	7.0	7.0	7.0	7.0	6.9	5.6	5.8	5.0	6.2	71.5	60.2
11	7.0	7.0	7.0	6.1	6.0	5.8	4.9	4.4	3.1	4.0	3.6	58.9	51.3
12	7.0	7.0	7.0	6.8	6.3	5.7	5.5	4.0	4.1	3.5	3.9	61.8	54.3
17	7.0	7.0	6.9	6.9	6.2	5.0	6.3	4.5	5.3	4.8	5.9	65.8	54.9
1968													
20	4.6	5.2	4.3	3.3	3.4	2.9	4.0	2.9	2.9	4.1	5.9	43.5	33.5
21	4.9	5.7	3.8	1.8	2.0	4.6	5.6	4.3	2.9	2.7	5.0	43.2	35.5
22	5.4	6.0	4.7	2.9	3.2	5.0	5.3	5.2	3.8	3.8	5.9	51.1	41.4
23	4.8	5.6	3.8	2.0	2.3	2.7	3.8	3.5	3.2	2.8	5.4	39.8	31.6
26	6.7	7.0	6.9	5.0	4.1	3.9	4.1	5.1	4.3	2.5	6.9	56.4	47.0
27	6.0	6.3	6.5	4.2	3.3	3.3	2.6	4.1	3.2	3.6	5.2	48.3	39.5
29	5.2	7.0	7.0	5.5	4.9	3.4	2.9	4.1	2.9	2.2	6.4	51.5	42.9
31	7.0	6.3	7.0	6.4	5.1	6.0	6.0	5.2	5.5	5.0	4.7	64.2	54.5
32	6.3	7.0	7.0	5.7	5.2	6.7	6.4	5.6	5.5	3.8	6.5	65.7	55.4
33	6.4	7.0	6.9	5.0	4.6	5.3	5.0	5.4	4.3	2.9	6.4	59.1	49.8
36	4.7	5.8	5.8	5.9	5.4	4.4	4.7	3.2	1.9	1.3	3.9	47.0	41.8
38	6.6	7.0	7.0	6.8	5.7	5.4	4.3	5.1	4.1	3.7	5.6	61.2	52.1
39	6.0	5.2	3.3	3.5	3.5	2.8	3.1	6.0	6.6	7.0	6.9	53.9	40.0
40	7.0	6.7	7.0	6.8	5.3	5.5	6.2	6.3	6.1	6.1	4.0	67.0	56.9

Table 40. (Continued)

Site no.	C. Relative photosynthesis (p/p_o) - Laing												
	6B	5B	4B	3B	2B	1B	1A	2A	3A	4A	5A	Σ 6B-5A	Σ 6B-3A
1967													
02	6.9	5.5	5.7	5.0	2.5	3.2	3.5	1.5	0.6	0.1	0.0	34.5	34.4
03	7.0	6.8	5.6	5.3	3.3	3.3	5.0	4.4	2.0	0.8	0.2	46.3	45.3
04	5.6	6.4	5.3	3.7	2.9	4.7	4.0	1.5	0.7	0.2	0.0	35.0	34.8
05	5.7	6.4	6.0	4.5	4.8	6.4	5.7	3.2	1.6	0.6	0.2	45.2	44.4
06	6.6	5.7	6.0	5.5	5.3	4.5	4.4	4.3	3.4	1.3	0.6	47.6	45.7
09	6.7	5.6	6.1	6.0	5.9	5.9	4.3	2.1	0.9	0.3	0.1	43.8	43.4
11	5.6	6.1	4.8	3.4	1.6	0.8	0.1	0.1	0.0	0.0	0.0	22.4	22.4
12	6.8	5.5	6.2	4.7	3.4	2.0	1.0	0.3	0.0	0.0	0.0	29.8	29.8
17	6.5	5.1	4.8	4.4	2.8	1.2	2.1	0.9	0.4	0.1	0.0	28.4	28.3
1968													
20	1.1	0.9	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.3	2.3
21	0.6	0.4	0.0	0.0	0.0	1.5	1.2	0.0	0.0	0.0	0.0	3.7	3.7
22	0.9	1.1	0.3	0.0	0.0	1.9	1.2	0.4	0.0	0.0	0.0	5.4	5.4
23	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.5
26	3.6	6.2	5.2	1.2	0.6	0.0	0.0	0.5	0.0	0.0	6.4	23.7	17.3
27	1.6	4.9	4.8	1.8	0.7	0.0	0.0	0.0	0.0	0.2	0.7	14.7	13.8
29	0.5	6.2	5.5	0.9	0.6	0.0	0.0	0.1	0.0	0.0	5.9	19.8	13.9
31	4.6	3.5	5.5	4.3	1.5	0.6	0.2	0.3	0.5	0.5	0.0	21.4	20.9
32	2.6	6.0	5.7	2.6	2.2	3.5	4.2	3.6	0.8	0.2	6.4	37.6	31.1
33	2.8	5.7	5.0	1.3	1.8	3.1	4.8	3.1	0.1	0.0	3.0	30.6	27.6
36	0.2	6.3	5.6	4.0	3.1	0.3	0.3	0.0	0.0	0.0	0.0	19.9	19.9
38	4.7	6.1	5.7	4.5	3.2	0.6	0.3	0.0	0.0	0.0	6.0	31.0	25.0
39	1.4	0.1	0.0	0.0	0.1	0.0	1.3	3.1	5.0	5.1	6.7	22.8	11.0
40	5.6	3.7	5.5	4.6	1.2	3.1	4.3	5.3	5.4	1.5	1.5	41.7	38.7

Table 40. (Continued)

Site no.	D. Relative photosynthesis (p/p_o) - Shaw modification												
	6B	5B	4B	3B	2B	1B	1A	2A	3A	4A	5A	Σ 6B-5A	Σ 6B-3A
1967													
02	7.0	6.5	6.6	6.3	3.5	5.7	5.6	3.8	3.0	1.7	3.1	52.8	48.0
03	7.0	7.0	6.5	6.8	6.6	4.1	6.2	6.0	4.0	3.1	1.7	59.2	54.3
04	6.5	6.9	6.6	4.8	4.2	6.4	5.7	3.4	2.8	3.0	3.2	53.5	47.3
05	6.6	6.9	7.0	5.3	6.0	7.0	6.6	4.4	4.0	3.8	4.2	61.9	53.9
06	7.0	6.9	6.8	6.7	6.2	5.7	6.5	5.9	5.5	3.6	4.9	65.8	57.2
09	7.0	6.8	6.9	6.9	6.8	6.9	6.2	4.2	3.4	2.1	3.4	60.6	55.0
11	6.6	6.7	6.4	5.0	4.1	4.9	3.1	2.1	0.8	0.8	0.3	40.8	39.7
12	7.0	6.7	6.8	6.0	4.8	4.4	3.7	2.8	1.3	0.4	0.5	44.4	43.5
17	6.9	6.5	5.3	6.3	4.9	3.2	5.3	2.2	3.2	2.0	2.9	48.6	43.7
1968													
20	2.8	1.3	0.4	0.2	0.3	0.3	1.0	0.1	0.4	2.1	4.2	13.1	6.8
21	1.3	3.0	0.1	0.0	0.1	3.5	4.3	1.1	1.0	0.2	2.3	17.1	14.5
22	2.2	3.8	1.0	0.1	0.8	3.8	3.6	3.3	1.2	1.3	3.3	24.4	19.8
23	1.1	2.2	0.2	0.0	0.3	0.4	1.6	0.7	0.6	0.5	2.7	10.2	7.0
26	4.5	7.0	6.2	1.9	1.9	1.6	1.7	4.0	1.2	0.1	7.0	37.2	30.1
27	3.2	4.7	5.8	2.3	1.0	0.4	0.5	2.9	0.6	2.0	3.6	26.9	21.4
29	1.4	6.9	6.7	2.1	2.3	1.5	0.8	3.0	0.1	0.7	6.0	31.4	24.7
31	5.7	4.7	6.7	5.0	3.4	3.2	3.1	4.3	3.8	3.1	1.5	44.6	40.0
32	3.7	6.8	6.8	3.2	3.7	5.4	5.1	4.8	3.3	1.2	7.0	51.1	42.9
33	3.2	5.8	5.0	2.1	2.5	4.3	4.8	4.5	1.9	0.2	6.3	40.6	34.1
36	0.5	6.0	5.4	4.4	2.7	2.0	2.1	1.0	0.0	0.0	1.6	25.8	24.1
38	5.4	6.8	6.8	6.0	4.0	2.8	2.7	3.1	1.2	0.9	6.2	45.9	38.8
39	2.3	2.9	1.2	1.1	1.6	1.0	3.6	4.5	6.2	6.5	7.0	37.8	24.3
40	6.5	4.6	6.7	5.2	2.1	4.7	5.5	5.5	6.5	3.8	2.1	53.2	47.3

Table 41. Correlation matrix showing relationships among variables measured on all plots

		1	2	3	4	5	6	7	8	9	10	11	12
1.	Yield	1.00											
2.	Soil N	0.14	1.00										
3.	Soil P	-.03	0.17	1.00									
4.	Soil K	-.02	0.19	0.65	1.00								
5.	Soil pH	-.01	-.10	-.34	-.45	1.00							
6.	Subsoil N	-.28	-.21	-.09	0.06	-.14	1.00						
7.	Subsoil P	-.04	0.11	0.73	0.68	0.39	0.20	1.00					
8.	Subsoil K	0.03	-.14	0.39	0.56	-.44	0.44	0.70	1.00				
9.	Subsoil pH	0.04	-.01	-.28	-.47	0.66	-.30	-.56	-.52	1.00			
10.	Stand	-.11	-.08	0.15	0.11	-.16	0.03	0.26	0.16	-.25	1.00		
11.	Past cropping	-.04	0.17	0.37	0.23	0.03	0.13	0.47	0.35	0.03	0.07	1.00	
12.	Planting date	0.32	0.11	-.18	-.11	0.09	-.31	0.00	-.10	-.14	0.07	-.11	1.00
13.	Weeds	0.34	0.02	-.18	-.07	0.09	-.18	0.01	0.12	0.00	-.14	0.03	0.62
14.	Soil yield pot.	0.03	0.07	0.42	0.52	-.49	0.22	0.75	0.69	-.60	0.40	0.19	0.08
15.	Barrenness	-.54	-.00	0.16	0.14	-.07	-.02	0.26	0.25	0.00	0.45	0.27	-.04
16.	Silking date	0.02	0.23	-.12	-.14	0.28	-.35	-.08	-.18	0.23	0.09	0.03	0.67
17.	Leaf N	-.01	-.06	-.02	-.03	0.06	0.20	-.20	-.08	0.08	-.12	-.18	-.33
18.	Leaf P	0.17	-.07	0.15	0.06	0.21	-.12	-.01	-.05	0.20	-.11	0.03	-.09
19.	Leaf K	-.37	-.03	0.31	0.46	-.31	0.35	0.36	0.30	-.34	0.23	0.05	-.47
20.	Root lodging, mod.	0.27	0.11	0.04	0.13	-.01	0.04	0.22	0.10	-.09	-.04	0.28	0.03
21.	Root lodging, sev.	0.14	0.12	0.04	0.17	-.00	0.04	0.20	0.14	-.05	-.05	0.12	0.13
22.	Stalk lodg., above	0.10	-.11	-.15	-.18	0.07	-.03	-.29	-.08	0.04	-.24	-.27	0.05
23.	Stalk lodg., below	0.03	-.15	-.06	0.06	-.07	0.07	-.10	-.01	-.14	0.06	-.17	-.01
24.	Soil H_2O, D_3	0.68	-.06	-.16	-.14	0.24	-.41	-.16	-.13	0.23	-.15	0.09	0.57

Table 41. (Continued)

		13	14	15	16	17	18	19	20	21	22	23	24
1.	Yield												
2.	Soil N												
3.	Soil P												
4.	Soil K												
5.	Soil pH												
6.	Subsoil N												
7.	Subsoil P												
8.	Subsoil K												
9.	Subsoil pH												
10.	Stand												
11.	Past cropping												
12.	Planting date												
13.	Weeds	1.00											
14.	Soil yield pot.	0.12	1.00										
15.	Barrenness	-.08	0.34	1.00									
16.	Silking date	0.37	-.01	0.30	1.00								
17.	Leaf N	-.34	-.07	-.24	-.23	1.00							
18.	Leaf P	-.18	-.02	-.14	-.01	0.50	1.00						
19.	Leaf K	-.18	0.36	0.25	-.36	0.24	0.12	1.00					
20.	Root lodging, mod.	0.15	0.22	-.08	-.10	-.17	-.06	-.04	1.00				
21.	Root lodging, sev.	0.20	0.21		0.06	0.09	-.04	0.44	1.00	1.00			
22.	Stalk lodg., above	-.04	-.22	-.24	-.08	0.22	0.20	-.24	-.24	-.13	1.00		
23.	Stalk lodg., below	-.04	0.01	-.15	-.15	0.15	0.07	0.02	-.12	-.09	0.39	1.00	
24.	Soil H_2O, D_3	0.59	-.13	-.35	-.25	-.22	0.19	-.56	0.32	0.21	0.09	-.01	1.00

Table 41a. Inverse matrix of 1 1/2 cube design with treatment levels coded from -2 to +2

	N	N^2	P	P^2	K	K^2	NP	NK	PK
N	0.0198								
N^2	0.0	0.0132							
P	0.0	0.0	0.0198						
P^2	0.0	-0.0025	0.0	0.0132					
K	0.0	0.0	0.0	0.0	0.0198				
K^2	0.0	-0.0025	0.0	-0.0025	0.0	0.0132			
NP	0.0	0.0	0.0	0.0	0.0	0.0	0.0082		
NK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0082	
PK	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0082

Table 42. Error mean squares of among sites and within sites variation for fertilizer regression coefficients in Model: Leaf N, P, or K = f(applied fertility)

Variable	df	Among sites Mean square	df	Within sites Mean square	F-ratio	Prob.
			A. Leaf N			
N	22	$1.674,551 \times 10^{-5}$	166	$0.013,361 \times 10^{-5}$	125.3	.005
N^2		$1.374,723 \times 10^{-11}$		$3.542,820 \times 10^{-11}$	<1	ns
P		$3.905,101 \times 10^{-5}$		$0.148,424 \times 10^{-5}$	26.31	.005
P^2		$6.429,372 \times 10^{-8}$		$0.437,320 \times 10^{-8}$	14.70	.005
K		$1.367,411 \times 10^{-5}$		$0.037,105 \times 10^{-5}$	36.85	.005
K^2		$5.795,733 \times 10^{-9}$		$0.273,315 \times 10^{-9}$	21.21	.005
NP		$4.563,389 \times 10^{-9}$		$0.260,541 \times 10^{-9}$	17.52	.005
NK		$1.997,002 \times 10^{-9}$		$0.065,137 \times 10^{-9}$	30.66	.005
PK		$2.804,083 \times 10^{-9}$		$0.072,374 \times 10^{-8}$	38.74	.005
			B. Leaf P			
N	22	$1.245,500 \times 10^{-7}$	166	$0.012,816 \times 10^{-7}$	97.18	.005
N^2		$1.896,808 \times 10^{-11}$		$0.033,984 \times 10^{-11}$	55.81	.005
P		$1.495,170 \times 10^{-6}$		$0.014,237 \times 10^{-6}$	105.0	.005
P^2		$1.544,453 \times 10^{-9}$		$0.041,949 \times 10^{-9}$	36.82	.005
K		$9.837,905 \times 10^{-10}$		$35.593,489 \times 10^{-10}$	<1	ns
K^2		$7.012,156 \times 10^{-11}$		$0.262,184 \times 10^{-11}$	26.75	.005
NP		$5.652,620 \times 10^{-11}$		$0.249,926 \times 10^{-11}$	22.62	.005
NK		$2.390,496 \times 10^{-11}$		$0.062,482 \times 10^{-11}$	38.26	.005

Table 42. (Continued)

Vari-able	df	Among sites Mean square	df	Within sites Mean square	F-ratio	Prob.
PK		$2.265,167 \times 10^{-10}$		$0.069,425 \times 10^{-10}$	32.63	.005
			C. Leaf K			
N	22	$5.117,499 \times 10^{-6}$	166	$0.253,562 \times 10^{-6}$	20.18	.005
N^2		$1.672,978 \times 10^{-9}$		$0.067,236 \times 10^{-9}$	24.88	.005
P		$5.583,373 \times 10^{-5}$		$0.281,680 \times 10^{-5}$	19.82	.005
P^2		$1.054,253 \times 10^{-7}$		$0.082,995 \times 10^{-7}$	12.70	.005
K		$2.679,478 \times 10^{-5}$		$0.070,418 \times 10^{-5}$	38.05	.005
K^2		$6.713,320 \times 10^{-9}$		$0.518,700 \times 10^{-9}$	12.94	.005
NP		$1.678,089 \times 10^{-8}$		$0.049,446 \times 10^{-8}$	33.94	.005
NK		$2.514,870 \times 10^{-9}$		$0.123,618 \times 10^{-9}$	20.34	.005
PK		$1.866,199 \times 10^{-8}$		$0.137,352 \times 10^{-8}$	13.59	.005

Table 43. Multiple regression statistics for the regression of b_N, b_P, and b_K from the model, Leaf N, P or K = f(N, N^2, ..., NK, PK), on selected uncontrolled factors which varied

Dependent variable	Independent variables	Regression coefficients[a]	t-values	R^2	Standard error
		A. Leaf N			
b_N	b_o	0.61308		.504	.00091
	R	0.23391	0.90		
	C	0.01090	0.14		
	n	-0.03628	1.31+		
	p	-0.01419	0.47		
	k	0.00570	0.72		
	n_s	-0.04796	1.16+		
	P_s	-0.00900	0.10		
	k_s	0.00005	0.01		
	a	0.60002	0.80		
	D	-0.09652	0.79		
	S	-0.10652	0.40		
	DS	0.00590	0.85		
b_P	b_o	-8.53929		.556	.00133
	R	-0.15839	0.42		
	C	0.11493	1.03+		
	n	0.05020	1.24+		
	p	0.03992	0.91		
	k	-0.00461	0.40		
	n_s	0.11045	1.84+++		

[a]Regression coefficients have been multiplied by 1000 to conserve space.

Table 43. (Continued)

Dependent variable	Independent variables	Regression coefficients	t-values	R^2	Standard error
b_P	p_s	-0.23056	1.81+++		
	k_s	-0.00793	0.66		
	a	-0.88553	0.81		
	D	-0.00208	0.01		
	S	0.06336	0.16		
	DS	-0.00139	0.14		
b_K	b_o	7.77972		.611	.00075
	R	0.31102	1.45++		
	C	0.02884	0.46		
	n	-0.02877	1.27+		
	p	-0.00092	0.04		
	k	0.00002	0.00		
	n_s	-0.02677	0.79		
	P_s	0.06832	0.96		
	k_s	-0.01185	1.76++		
	a	-0.38454	0.63		
	D	-0.07539	0.76		
	S	-0.00033	1.51++		
	DS	0.00368	0.65		
		B. Leaf P			
b_N	b_o	-0.51366		.392	.000087
	R	0.01736	0.69		
	C	0.00958	1.31+		
	n	-0.00201	0.76		
	p	-0.00080	0.28		
	k	0.00041	0.54		

Table 43. (Continued)

Dependent variable	Independent variables	Regression coefficients	t-values	R^2	Standard error
n_s	n_s	-0.00493	1.26+		
	p_s	-0.00375	0.45		
	k_s	-0.00039	0.50		
	a	-0.01123	0.16		
	D	-0.00031	0.03		
	S	-0.00001	0.25		
	DS	0.00008	0.12		
b_P	b_o	-0.50585		.708	.00021
	R	-0.11827	1.97+++		
	C	-0.01609	0.91		
	n	0.00386	0.60		
	p	-0.00119	0.17		
	k	0.00075	0.41		
	n_s	0.01324	1.40++		
	p_s	-0.02629	1.31+		
	k_s	0.00321	1.69++		
	a	0.33544	1.95+++		
	D	-0.02864	1.03+		
	S	-0.00520	0.09		
	DS	0.00133	0.84		
b_K	b_o	0.09724		.611	
	R	0.00208	1.11+		
	C	-0.00066	1.21+		
	n	-0.00028	1.43++		
	p	-0.00035	1.65++		
	k	0.00009	1.66++		

Table 43. (Continued)

Dependent variable	Independent variable	Regression coefficients	t-values	R^2	Standard error
	n_s	-0.00051	1.74++		
	p_s	0.00104	1.68++		
	k_s	-0.00006	0.96		
	a	-0.00369	0.69		
	D	0.00033	0.38		
	S	-0.00005	0.02		
	DS	-0.00002	0.44		
		C. Leaf K			
b_N	b_o	0.98707		.398	.00555
	R	-0.05415	0.34		
	C	0.01361	0.29		
	n	-0.01313	0.78		
	p	-0.00790	0.43		
	k	0.00331	0.69		
	n_s	0.02715	1.09+		
	p_s	-0.01077	0.20		
	k_s	-0.00117	0.23		
	a	-0.11342	0.25		
	D	-0.05917	0.80		
	S	-0.09088	0.57		
	DS	0.00388	0.80		
b_P	b_o	-2.15725		.470	.00172
	R	-0.41197	0.84		
	C	-0.07641	0.53		
	n	-0.0422	0.77		
	p	0.01251	0.22		

Table 43. (Continued)

Dependent variable	Independent variable	Regression coefficients	t-values	R^2	Standard error
	k	0.00543	0.36		
	n_s	0.12125	1.56++		
	P_s	-0.06272	0.38		
	k_s	-0.01153	0.74		
	a	1.20654	0.86		
	D	-0.11055	0.48		
	S	0.25703	0.52		
	DS	0.00469	0.36		
b_K	b_o	10.1053		.567	.00108
	R	0.14371	0.47		
	C	-0.00792	0.09		
	n	-0.04795	1.46++		
	p	-0.03366	0.95		
	k	-0.00192	0.20		
	n_s	-0.03515	0.72		
	p_s	0.11615	1.13+		
	k_s	-0.01251	1.29+		
	a	-0.46486	0.53		
	D	0.08173	0.57		
	S	0.03648	0.12		
	DS	-0.00551	0.67		

Table 44. Multivariate regression models used in determining a general leaf content equation for corn growing on Marshall and Monona soils

Model[a] no.	Regression variates	Regression[b] coefficients	t-value	R^2	Standard error
		A. Leaf N			
1	b_o	2.7756		.209	.229
	N	0.15492	11.4***		
	N^2	-0.00089	4.02***		
	P	-0.04039	0.89		
	P^2	0.00239	0.97		
	K	-0.02889	1.27+		
	K^2	0.00019	0.30		
	NP	0.00019	0.32		
	NK	-0.00015	0.48		
	PK	0.00095	0.95		
2	b_o	2.4656		.192	.231
	n	0.01858	0.21		
	p	0.58316	6.47***		
	k	0.04351	2.44*		
	a	6.0970	1.96*		
	n_s	1.6469	7.84***		
	p_s	-2.9929	8.18***		
	k_s	0.00464	0.14		

[a]Model numbers correspond to those listed in Table 21.

[b]With the exception of b_o, listed RC's for leaf N and K have been multiplied by 100 and RC's for leaf P have been multiplied by 1000.

Table 44. (Continued)

Model no.	Regression variates	Regression coefficients	t-value	R^2	Standard error
	a_s	-4.6345	1.20+		
3	b_o	3.0644		.216	.228
	R	-8.8810	2.04*		
	T	-2.5832	4.28***		
	W	-6.8488	4.80***		
	S	-0.88523	1.71+++		
	C	0.16782	0.13		
	R^2	0.80541	1.06+		
	T^2	0.07825	3.28***		
	C^2	0.00119	0.18		
	S^2	0.03781	1.77+++		
4	b_o	2.5153		.209	.227
	D	2.2070	8.97***		
	D^2	-0.03824	10.8***		
5	b_o	2.4769		.396	.201
	N	0.15167	12.7***		
	N^2	-0.00095	4.85***		
	P	-0.05865	1.47++		
	P^2	0.00208	0.96		
	K	-0.02764	1.39++		
	K^2	0.00024	0.45		
	n	0.01508	0.20		
	p	0.54185	6.90***		
	k	0.05194	3.34***		
	a	4.9825	1.84+++		

Table 44. (Continued)

Model no.	Regression variates	Regression coefficients	t-value	R^2	Standard error
	n_s	1.6548	9.07**		
	p_s	-2.9155	9.15***		
	k_s	-0.00320	0.11		
	a_s	-3.3607	1.00+		
6	b_o	0.13677		.588	.173
	N	0.14742	14.2***		
	N^2	-0.00102	6.05***		
	P	-0.05736	1.67+++		
	P^2	0.00222	1.19+		
	K	-0.00988	0.57		
	K^2	0.00039	0.84		
	NP	0.00028	0.61		
	NK	-0.00008	0.33		
	PK	0.00085	1.12		
	n	-0.05228	0.76		
	p	0.44915	6.13***		
	k	0.04036	2.96**		
	a	11.649	4.77***		
	n_s	1.0103	5.53***		
	p_s	-3.4151	9.75***		
	k_s	0.01121	0.40		
	a_s	1.7292	0.51		
	R	-1.2134	1.42++		
	T	-0.13774	0.76		
	W	-8.6555	7.85***		
	S	1.3008	4.18***		
	C	2.2049	9.51***		
	B	0.47474	4.96***		

Table 44. (Continued)

Model no.	Regression variates	Regression coefficient	t-value	R^2	Standard error
7	b_o	-0.19112		0.571	.171
	N	0.14096	13.7***		
	N^2	-0.00099	5.97***		
	P	-0.05928	1.75+++		
	P^2	0.00245	1.33++		
	K	-0.01094	0.64		
	K^2	0.00034	0.74		
	n	1.4486	2.61**		
	n^2	-0.01186	2.96**		
	p	0.35226	4.35***		
	k	0.05735	4.26***		
	a	16.802	6.13***		
	n_s	-0.16938	0.69		
	p_s	-2.4750	6.06***		
	k_s	-0.00629	0.21		
	a_s	0.29789	0.09		
	R	-21.065	5.26***		
	C	1.8795	7.24***		
	S	-0.51057	1.28++		
	B	-0.71032	6.00***		
	R^2	3.5395	5.22***		
	S^2	0.00576	0.34		
	H	-0.10282	0.07		
	D	1.3924	4.99***		
	D^2	-0.03016	7.30***		
8	b_o	0.05232		.595	.166
	N	0.20054	2.22*		

Table 44. (Continued)

Model no.	Regression variates	Regression coefficients	t-value	R^2	Standard error
	N^2	-0.00089	0.35		
	P	-0.05256	1.62++		
	P^2	0.00231	1.34++		
	K	-0.00724	0.44		
	n	-0.15107	2.32*		
	p	0.35094	4.72***		
	k	0.05296	4.29***		
	a	15.489	7.26***		
	n_s	-0.04430	0.16		
	p_s	-2.6276	7.20***		
	R	-15.555	3.96***		
	T	-0.03349	0.19		
	W	-4.8447	4.23***		
	C	2.0151	7.40***		
	S	-0.85722	2.89**		
	B	0.59332	5.63		
	R^2	2.5292	3.89***		
	D	0.90336	3.49***		
	D^2	-0.02001	4.94***		
	RN	-0.00573	0.66		
	nN	-0.00278	3.42***		
	DN	-0.00019	0.28		
	RN^2	0.00002	0.14		
	n_sN^2	0.00003	0.85		
	CN^2	-0.00001	0.42		
	DN^2	0.00001	1.23		
	SN	0.00832	2.27*		

Table 44. (Continued)

Model no.	Regression variates	Regression coefficients	t-value	R^2	Standard error
		B. Leaf P			
1	b_o	0.27511		.091	.023
	N	0.03983	2.90**		
	N^2	-0.00027	1.22+		
	P	0.29555	6.45***		
	P^2	-0.00141	0.56		
	K	-0.02153	0.94		
	K^2	-0.00041	0.66		
	NP	0.00087	1.44++		
	NK	-0.00003	0.10		
	PK	0.00022	0.22		
2	b_o	0.15294		.138	.023
	n	-0.21434	2.52*		
	p	0.38890	4.43***		
	k	0.04305	2.45*		
	a	13.204	4.36***		
	n_s	-0.14261	0.70		
	p_s	-0.79983	2.24*		
	k_s	0.01608	0.49		
	a_s	54.353	1.44++		
3	b_o	0.13617		.075	.023
	R	7.7647	1.74+++		
	T	0.07624	0.12		
	W	-7.3294	5.01***		
	S	-1.6537	3.12**		
	C	2.9697	2.29*		

Table 44. (Continued)

Model no.	Regression variates	Regression coefficients	t-value	R^2	Standard error
	R^2	-1.1909	1.53++		
	T^2	0.01634	0.67		
	C^2	-0.1389	2.09*		
	S^2	-0.00477	0.22		
4	b_o	0.23948		.105	.023
	D	1.8908	7.66***		
	D^2	-0.02363	6.66***		
5	b_o	0.15556		.220	.022
	N	0.03587	2.80**		
	N^2	-0.00035	1.66+++		
	P	0.28654	6.72***		
	P^2	-0.00152	0.66		
	K	-0.02091	0.98		
	K^2	-0.00040	0.70		
	n	-0.22126	2.73**		
	p	0.35533	4.22***		
	k	0.04408	2.65**		
	a	13.025	4.50***		
	n_s	-0.16230	0.83		
	p_s	-0.70153	2.05**		
	k_s	0.01338	0.43		
	a_s	5.7676	1.60++		
6	b_o	0.00142		.368	.020
	N	0.03006	2.56**		
	N^2	-0.00043	2.28*		
	P	0.28520	7.36***		

Table 44. (Continued)

Model no.	Regression variates	Regression coefficients	t-value	R^2	Standard error
	P^2	-0.00143	0.68		
	K	0.00071	0.04		
	K^2	-0.00022	0.41		
	NP	0.00089	1.74+++		
	NK	0.00025	0.29		
	PK	0.00025	0.29		
	n	-0.29836	3.85***		
	p	0.33909	4.11***		
	k	0.04132	2.69**		
	a	16.125	5.86***		
	n_s	-0.45846	2.23*		
	p_s	-1.4318	3.63***		
	k_s	0.04409	1.40++		
	a_s	15.597	4.11***		
	R	0.06200	0.06		
	T	0.75684	3.69***		
	W	-9.8527	7.93***		
	S	-1.2926	3.68***		
	B	-0.58012	5.38***		
	C	1.9607	7.51***		
7	b_o	-0.04819		.426	.019
	N	0.03093	2.75**		
	N^2	-0.00042	2.30+++		
	P	0.28112	7.59***		
	P^2	-0.00082	0.41		
	K	-0.01073	0.58		
	K^2	-0.00032	0.64		

Table 44. (Continued)

Model no.	Regression variates	Regression coefficients	t-values	R^2	Standard error
	n	1.8249	3.02***		
	n^2	-0.01613	3.69***		
	P	0.24436	2.77**		
	k	0.05687	3.87***		
	a	23.072	7.72***		
	n_s	-1.3740	5.11***		
	p_s	0.37964	0.85		
	k_s	-0.01775	0.54		
	a_s	5.3668	1.48++		
	R	-34.876	7.98***		
	S	-0.11436	2.64**		
	C	1.0413	3.68***		
	B	-0.30660	2.37*		
	R^2	5.6388	7.61***		
	S^2	0.04995	2.70**		
	H	-1.1701	0.75		
	D	2.6868	8.82***		
	D^2	-0.03987	8.85***		
8	b_o	0.00142		.474	.018
	N	0.25865	1.63++		
	N^2	-0.00045	2.49*		
	P	0.77502	3.35***		
	P^2	-0.00973	2.06*		
	K	-0.01096	0.59		
	n	-0.34887	4.64***		
	p	0.21634	2.18*		
	k	0.04657	3.23**		

Table 44. (Continued)

Model no.	Regression variates	Regression coefficients	t-value	R^2	Standard error
	a	23.589	8.32***		
	n_s	-1.0351	4.03***		
	p_s	-0.02344	0.06		
	a_s	4.8023	1.33++		
	R	-27.241	6.24***		
	W	-7.9901	6.25***		
	S	-1.2709	2.94**		
	C	1.4878	5.16***		
	B	-0.13381	1.04+		
	R^2	4.2757	5.76***		
	S^2	0.0100	0.53		
	D	2.0849	7.02***		
	D^2	-0.02707	5.64***		
	RN	-0.01066	1.09+		
	aN	-0.02948	1.18+		
	DN	-0.00019	0.25		
	p_sp	-0.01785	1.95+++		
	pP	-0.00246	0.87		
	nP	0.00118	0.40		
	DP	-0.00703	2.82**		
	pP^2	0.00011	1.12+		
	D^2P^2	0.000003	1.83+++		
		C. Leaf K			
1	b_o	2.2593		.038	.318
	N	0.02076	1.10+		
	N^2	-0.00002	0.07		
	P	0.06020	0.96		

Table 44. (Continued)

Model no.	Regression variates	Regression coefficients	t-values	R^2	Standard error
	P^2	-0.00016	0.05		
	K	0.13000	4.13***		
	K^2	-0.00089	1.04+		
	NP	-0.00025	0.30		
	NK	0.00037	0.89		
	PK	0.00126	0.90		
2	b_o	2.3018		.362	.258
	n	-0.28156	2.90**		
	p	0.11191	1.11+		
	k	0.17366	8.71***		
	a	-8.9807	2.59*		
	n_s	2.3439	9.99***		
	p_s	0.55797	1.36++		
	k_s	-0.19329	5.18***		
	a_s	0.06207	0.01		
3	b_o	0.01841		.503	.228
	R	-25.809	5.92***		
	T	-4.2579	7.05***		
	W	-9.4940	6.64***		
	S	0.81475	1.57++		
	C	3.3366	2.63*		
	R^2	4.3223	5.69***		
	T^2	0.10338	4.33***		
	C^2	-0.00521	0.80		
	S^2	-0.01749	0.82		
4	b_o	2.6521		.310	.267

Table 44. (Continued)

Model no.	Regression variates	Regression coefficients	t-value	R^2	Standard error
	D	-1.1101	3.84***		
	D^2	-0.00114	0.27		
5	b_o	2.3136		.400	.252
	N	0.02187	1.46++		
	N^2	-0.00017	0.71		
	P	0.03847	0.77		
	P^2	0.00010	0.04		
	K	0.13608	5.46***		
	K^2	-0.00079	1.17+		
	n	-0.29198	3.07**		
	p	0.09765	0.99		
	k	0.17760	9.11***		
	a	-9.0115	2.66**		
	n_s	2.3429	10.2***		
	p_s	0.58180	1.46++		
	k_s	-0.19642	5.39***		
	a_s	0.14816	0.04		
6	b_o	1.6086		.633	.199
	N	0.03220	2.70**		
	N^2	-0.00017	0.86		
	P	0.05992	1.52++		
	P^2	0.00038	0.18		
	K	0.12828	6.48***		
	K^2	-0.00091	1.69+++		
	NP	-0.00011	0.21		
	NK	0.00057	2.18*		

Table 44 (Continued)

Model no.	Regression variates	Regression coefficients	t-values	R^2	Standard error
	PK	0.00092	1.05+		
	n	-0.26823	3.39**		
	p	-0.16507	1.96*		
	k	0.15658	10.0***		
	a	3.2184	1.15+		
	n_s	1.1691	5.58***		
	p_s	0.66370	1.65+++		
	k_s	-0.17738	5.54***		
	a_s	-10.016	2.59*		
	R	-3.5541	3.62***		
	T	-1.5527	7.44***		
	W	-7.7718	6.14***		
	S	-0.07748	0.22		
	C	1.1315	4.26***		
	B	0.61335	4.60***		
7	b_o	-0.25976		.608	.205
	N	0.01733	1.40++		
	N^2	-0.00016	0.81		
	P	0.03641	0.89		
	P^2	0.00002	0.01		
	K	0.13889	6.77***		
	K^2	-0.00080	1.43++		
	n	0.85690	1.29++		
	n^2	-0.00964	2.00*		
	p	0.18880	1.94+++		
	k	0.17870	11.0***		
	a	11.006	3.34***		

Table 44. (Continued)

Model no.	Regression variates	Regression coefficients	t-value	R^2	Standard error
	n_s	0.83463	2.82**		
	p_s	-0.88814	1.81+++		
	k_s	-0.06344	1.76+++		
	a_s	1.3198	0.33		
	R	-33.330	6.92***		
	S	0.74988	1.57++		
	B	-0.08443	0.59		
	C	1.7931	5.74**		
	R^2	5.6220	6.89***		
	S^2	-0.00604	0.30		
	H	7.9322	4.59***		
	D	-1.0299	3.07**		
	D^2	0.00001	0.00		
8	b_o	0.72311		.662	.191
	N	0.04646	0.86		
	P	0.05033	1.70+++		
	K	0.23310	4.37***		
	K^2	-0.00080	2.05*		
	NK	-0.00130	1.28+		
	n	-0.34678	5.71***		
	p	-0.05402	0.84		
	k	0.13148	11.4***		
	a	6.7437	3.24**		
	n_s	0.41569	2.22*		
	p_s	0.29076	0.96		
	k_s	-0.32503	2.98**		
	R	-23.864	6.76***		
	T	-1.0375	5.96***		

Table 44. (Continued)

Model no.	Regression variates	Regression coefficients	t-values	R^2	Standard error
	W	-4.1895	4.14***		
	S	0.00039	1.42++		
	C	1.2529	6.11***		
	B	0.18776	1.89+++		
	R^2	3.7310	6.21***		
	D	-0.31072	3.77***		
	H	0.57960	0.43		
	RN	0.00526	0.67		
	nN	-0.00066	0.88		
	RK	-0.00743	0.57		
	kK	-0.00042	2.30*		
	nNK	0.00003	1.74++		

APPENDIX B. TABLE 45. DATA FROM ALL PLOTS IN YIELD AND LEAF STUDIES

The following explanations of symbols apply to the data which are recorded on the following 46 pages.

TRT NO.	Applied N, P, K treatments as given in Table 6
STRESS DAYS 6B-3A	Index developed by Dale for period 6 weeks before to 3 weeks after silking
NONSTRESS INDEX	Modification of Dale's index by regarding the actual value of stress ratio for the period 6 weeks before to 3 weeks after silking
REL. PS SHAW	Shaw's modification of Laing's relative photosynthesis index for period 6 weeks before to 3 weeks after silking
SILK. DATE AUG1=1	Date at which 75% of plants were showing silks were coded around July 31 equal to 0
TOTAL ROOT LODG%	Percentage of plants which formed an angle with the ground of 60° or less
TOTAL STALK LODG%	Percentage of plants which were broken off either above or below the ear
ROOT SIZE	Root rating for size (recovery) at sites of 2nd or more year consecutive corn, as defined in Table 4
ROOT DAMAGE	Root rating for damage by corn rootworm at sites of 2nd or more year consecutive corn, as defined in Table 4
PLANT. DATE	Numbers in this column represent the day in May which seed was planted
PAST CROPPING	Coded values as defined in Table 2
SOIL YIELD POT.	Soil yielding potential (bu/A) as given in Table 1

WEEDS 300 lb/ UNIT	Coded values of weed infestation as defined in Table 3
SOIL MOIST. 4=LOW	Dummy moisture variable with values 1-4 used at site 40 only

SITE NO. 2

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6B-3A	NON-STRESS INDEX	REL. PS SHAW
1	83.7	13400	17.0	70	17	50	19	626	178	6.20	6.80	25	57.25	47.98
2	105.1	16300	12.0	67	17	35	19	258	178	6.45	6.80	25	57.25	47.98
3	111.8	16700	7.8	64	17	49	19	224	178	6.20	6.80	25	57.25	47.98
4	71.6	16000	28.5	66	17	50	19	408	178	6.20	6.80	25	57.25	47.98
5	101.7	15700	10.4	58	17	35	19	462	178	6.40	6.80	25	57.25	47.98
6	89.0	14400	11.3	53	17	26	19	194	178	6.55	6.80	25	57.25	47.98
7	57.3	14700	44.4	55	17	26	19	246	178	6.70	6.80	25	57.25	47.98
8	53.2	14400	36.3	60	17	28	19	254	178	6.55	6.80	25	57.25	47.98
9	114.2	15700	10.4	59	17	32	19	202	178	6.50	6.80	25	57.25	47.98
10	116.1	15000	13.0	66	17	52	19	273	178	6.50	6.80	25	57.25	47.98
11	104.7	15700	6.2	62	17	32	19	295	178	6.45	6.80	25	57.25	47.98
12	77.8	15400	31.9	79	17	34	19	292	178	6.65	6.80	25	57.25	47.98
13	97.3	16300	24.0	63	17	50	19	568	178	6.20	6.80	25	57.25	47.98
14	86.6	13700	16.7	70	17	38	19	279	178	6.75	6.80	25	57.25	47.98
15	72.9	15700	16.7	68	17	48	19	334	178	6.25	6.80	25	57.25	47.98
16	96.1	16000	10.2	76	17	53	19	314	178	6.00	6.80	25	57.25	47.98
17	110.3	14000	6.9	67	17	42	19	251	178	6.60	6.80	25	57.25	47.98
18	103.5	16000	14.2	56	17	28	19	197	178	6.70	6.80	25	57.25	47.98
19	105.8	14400	19.8	62	17	53	19	515	178	6.25	6.80	25	57.25	47.98
20	105.3	15000	21.7	60	17	53	19	219	178	6.20	6.80	25	57.25	47.98
21	111.0	16000	8.2	61	17	44	19	252	178	6.05	6.80	25	57.25	47.98
22	71.5	15700	33.3	57	17	38	19	291	178	6.40	6.80	25	57.25	47.98
23	100.0	16000	12.2	65	17	40	19	299	178	6.50	6.80	25	57.25	47.98
24	110.4	15400	4.2	59	17	28	19	306	178	6.55	6.80	25	57.25	47.98
25	88.1	14000	16.3	66	17	52	19	341	178	6.00	6.80	25	57.25	47.98

SITE NO. 2(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD FCT.	WEEDS 300#/UNIT
1	6	2.45	0.292	2.50	6.6	6.7	2.8	2.2	12	5.0	102	1.0
2	-2	2.70	0.285	2.39	0.0	1.4	3.4	2.4	12	5.0	102	1.0
3	-1	2.58	0.262	2.16	0.0	3.9	4.0	2.2	12	5.0	102	1.0
4	6	2.40	0.270	2.21	11.6	1.4	2.8	3.2	12	5.0	102	1.0
5	1	2.75	0.292	2.80	0.0	10.3	3.8	2.4	12	5.0	102	1.0
6	6	2.52	0.268	2.04	4.2	2.8	3.8	2.8	12	5.0	102	1.0
7	7	2.43	0.300	2.06	34.3	1.6	2.2	3.8	12	5.0	102	1.0
8	9	2.41	0.280	2.24	43.9	0.0	2.0	4.2	12	5.0	102	1.0
9	3	2.68	0.289	2.44	2.7	2.8	4.0	2.2	12	5.0	102	1.0
10	-2	2.53	0.270	2.46	3.0	7.4	3.6	2.2	12	5.0	102	1.0
11	-1	2.55	0.300	2.29	0.0	8.9	3.0	2.8	12	5.0	102	1.0
12	6	2.54	0.280	2.21	7.1	2.9	3.6	3.2	12	5.0	102	1.0
13	1	2.57	0.275	2.68	0.0	5.6	2.6	2.4	12	5.0	102	1.0
14	1	2.64	0.285	2.24	4.8	8.0	3.1	2.8	12	5.0	102	1.0
15	5	2.56	0.290	2.10	1.4	2.8	3.0	2.8	12	5.0	102	1.0
16	3	2.35	0.280	2.33	0.0	2.8	3.8	2.2	12	5.0	102	1.0
17	-1	2.76	0.280	2.03	0.0	11.1	3.6	2.4	12	5.0	102	1.0
18	2	2.28	0.260	2.78	2.4	0.0	3.0	2.5	12	5.0	102	1.0
19	1	2.51	0.258	2.64	8.0	9.4	2.6	3.0	12	5.0	102	1.0
20	5	2.51	0.262	2.32	1.5	5.9	3.8	2.8	12	5.0	102	1.0
21	-2	2.34	0.254	2.49	1.3	0.0	3.2	2.8	12	5.0	102	1.0
22	7	2.60	0.270	2.32	8.6	0.0	3.5	2.5	12	5.0	102	1.0
23	1	2.52	0.262	2.45	0.0	10.8	3.4	2.6	12	5.0	102	1.0
24	-1	2.63	0.283	2.09	0.0	5.9	3.2	2.4	12	5.0	102	1.0
25	4	2.67	0.270	2.22	3.4	10.3	3.2	3.0	12	5.0	102	1.0

SITE NO. 3

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6B-3A	NON-STRESS INDEX	REL. PS SHAW
1	139.6	16300	6.0	97	20	28	21	260	186	6.55	6.35	14	59.92	54.33
2	149.4	15000	0.0	76	20	28	21	365	186	6.55	6.35	14	59.92	54.33
3	128.5	16000	0.0	64	20	30	21	326	186	6.10	6.35	14	59.92	54.33
4	132.1	15400	6.4	74	20	28	21	311	186	6.50	6.35	14	59.92	54.33
5	135.1	14400	4.5	66	20	35	21	335	186	6.15	6.35	14	59.92	54.33
6	129.2	14000	2.3	47	20	30	21	297	186	6.45	6.35	14	59.92	54.33
7	122.4	15700	6.2	87	20	38	21	340	186	6.55	6.35	14	59.92	54.33
8	115.3	15400	0.0	62	20	40	21	374	186	6.15	6.35	14	59.92	54.33
9	157.6	15700	0.0	84	20	31	21	328	186	6.15	6.35	14	59.92	54.33
10	154.0	15700	0.0	56	20	26	21	364	186	6.40	6.35	14	59.92	54.33
11	104.7	16300	0.0	59	20	40	21	432	186	6.20	6.35	14	59.92	54.33
12	143.7	15000	4.3	62	20	28	21	370	186	6.65	6.35	14	59.92	54.33
13	150.5	15400	0.0	62	20	42	21	486	186	6.10	6.35	14	59.92	54.33
14	135.5	14000	0.0	61	20	21	21	278	180	6.60	6.35	14	59.92	54.33
15	139.0	15400	4.2	91	20	36	21	214	186	6.25	6.35	14	59.92	54.33
16	141.4	16000	0.0	79	20	25	21	307	186	6.45	6.35	14	59.92	54.33
17	152.1	16300	2.0	77	20	28	21	322	186	6.20	6.35	14	59.92	54.33
18	139.6	15400	6.4	65	20	35	21	341	186	6.35	6.35	14	59.92	54.33
19	105.8	15700	0.0	81	20	26	21	309	186	6.65	6.35	14	59.92	54.33
20	122.2	14700	4.4	67	20	30	21	382	186	6.60	6.35	14	59.92	54.33
21	129.5	13700	2.4	83	20	34	21	334	183	6.60	6.35	14	59.92	54.33
22	141.1	15000	4.3	67	20	33	21	344	186	6.15	6.35	14	59.92	54.33
23	131.4	14000	0.0	73	20	34	21	388	186	6.35	6.35	14	59.92	54.33
24	149.2	16000	2.0	85	20	32	21	352	186	6.15	6.35	14	59.92	54.33
25	128.0	15700	2.1	76	20	28	21	356	186	6.30	6.35	14	59.92	54.33

SITE NO. 3(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAMAGE	PLANT. DATE MAY1=1	PAST CROPPING	SOIL YIELD PCT.	WEEDS 300#/UNIT
1	-6	2.76	0.276	2.04	41.4	1.4	3.6	3.0	11	3.0	109	2.0
2	-6	2.65	0.247	1.86	44.3	0.0	3.7	2.7	11	3.0	109	2.0
3	-6	2.42	0.238	2.76	52.8	1.4	3.2	3.0	11	3.0	109	2.0
4	-6	2.53	0.250	2.27	63.1	3.1	3.8	2.8	11	3.0	109	2.0
5	-6	2.59	0.262	2.14	57.9	0.0	3.0	3.0	11	3.0	109	2.0
6	-6	2.75	0.270	2.54	37.1	0.0	3.6	2.6	11	3.0	109	2.0
7	-6	2.38	0.250	2.00	63.2	0.0	3.0	3.4	11	3.0	109	2.0
8	-2	2.06	0.230	2.24	18.8	0.0	2.0	4.0	11	3.0	109	2.0
9	-6	2.70	0.262	2.25	7.0	0.0	4.5	2.0	11	3.0	109	2.0
10	-6	2.42	0.238	2.38	6.7	4.0	3.2	2.0	11	3.0	109	2.0
11	-6	2.55	0.250	2.08	24.3	1.5	3.2	2.8	11	3.0	109	2.0
12	-6	2.53	0.247	2.02	40.7	1.6	3.6	3.0	11	3.0	109	2.0
13	-4	2.36	0.245	2.36	45.2	0.0	3.2	3.2	11	3.0	109	2.0
14	-6	2.65	0.270	2.10	56.7	0.0	4.0	2.6	11	3.0	109	2.0
15	-6	2.37	0.247	2.28	3.8	0.0	4.5	2.0	11	3.0	109	2.0
16	-6	2.36	0.254	2.02	34.2	0.0	3.2	2.8	11	3.0	109	2.0
17	-6	2.21	0.243	2.13	20.0	0.0	3.4	2.6	11	3.0	109	2.0
18	-6	2.42	0.250	2.42	35.6	4.1	4.0	2.6	11	3.0	109	2.0
19	-6	2.61	0.247	1.97	30.6	1.4	3.4	2.8	11	3.0	109	2.0
20	-6	2.62	0.230	2.18	43.1	1.5	4.4	2.2	11	3.0	109	2.0
21	-6	2.73	0.262	2.13	59.3	1.7	3.6	3.0	11	3.0	109	2.0
22	-6	2.47	0.247	2.07	35.9	0.0	4.2	2.2	11	3.0	109	2.0
23	-6	2.16	0.254	2.38	34.8	0.0	3.2	3.2	11	3.0	109	2.0
24	-6	2.46	0.247	2.15	51.4	4.1	3.4	2.8	11	3.0	109	2.0
25	-6	2.33	0.250	2.30	62.0	1.4	3.6	2.4	11	3.0	109	2.0

SITE NO. 4

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 68-3A	NON-STRESS INDEX	REL. PS SHAW
1	95.8	19300	10.2	53	14	37	17	365	183	5.80	6.00	23	57.02	47.31
2	124.6	19900	11.5	61	14	54	17	394	183	5.95	6.00	23	57.02	47.31
3	102.3	19900	13.1	64	14	26	17	299	183	5.90	6.00	23	57.02	47.31
4	96.4	20300	16.1	64	14	46	17	317	183	5.90	6.00	23	57.02	47.31
5	116.7	20300	9.7	53	14	34	17	233	183	5.95	6.00	23	57.02	47.31
6	117.9	19600	8.3	58	14	30	17	410	183	6.05	6.00	23	57.02	47.31
7	92.5	19600	19.7	56	14	51	17	288	183	5.90	6.00	23	57.02	47.31
8	59.4	18900	24.1	50	14	26	17	350	183	5.85	6.00	23	57.02	47.31
9	98.2	19900	18.0	65	14	30	17	242	183	5.90	6.00	23	57.02	47.31
10	118.8	19900	9.8	58	14	38	17	390	183	6.05	6.00	23	57.02	47.31
11	119.9	20300	14.5	64	14	46	17	378	183	5.95	6.00	23	57.02	47.31
12	101.1	19600	15.0	58	14	36	17	349	183	5.95	6.00	23	57.02	47.31
13	128.0	18000	5.5	58	14	53	17	352	183	6.00	6.00	23	57.02	47.31
14	98.3	20300	16.1	58	14	54	17	271	183	5.90	6.00	23	57.02	47.31
15	88.7	19600	11.7	59	14	58	17	309	183	5.95	6.00	23	57.02	47.31
16	111.0	19600	8.3	56	14	44	17	370	183	5.85	6.00	23	57.02	47.31
17	110.7	20600	14.3	52	14	58	17	276	183	5.90	6.00	23	57.02	47.31
18	103.2	19300	20.3	49	14	38	17	411	183	5.95	6.00	23	57.02	47.31
19	128.7	21900	7.5	49	14	36	17	380	183	6.00	6.00	23	57.02	47.31
20	104.8	19300	13.6	70	14	54	17	250	183	5.90	6.00	23	57.02	47.31
21	102.6	21600	12.1	51	14	31	17	278	183	6.00	6.00	23	57.02	47.31
22	98.5	20600	19.0	59	14	38	17	398	183	5.90	6.00	23	57.02	47.31
23	114.3	18000	9.1	86	14	34	17	447	183	6.05	6.00	23	57.02	47.31
24	96.0	19300	15.3	55	14	42	17	221	183	5.95	6.00	23	57.02	47.31
25	105.4	19800	13.5	59	14	41	17	332	183	5.95	6.00	23	57.02	47.31

SITE NO. 4(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAMAGE	PLANT. DATE MAY1=1	PAST CROPPING	SOIL YIELD POT.	WEEDS 300#/UNIT
1	6	2.54	0.247	2.08	7.0	3.5	3.4	2.8	25	2.7	104	1.0
2	5	2.59	0.250	2.44	1.2	12.8	4.0	2.4	25	2.7	104	1.0
3	6	2.47	0.230	2.22	2.2	3.3	4.0	2.8	25	2.7	104	2.0
4	7	2.53	0.262	2.04	7.5	5.4	3.4	2.8	25	2.7	104	1.0
5	1	2.26	0.250	1.74	0.0	8.0	3.8	2.4	25	2.7	104	2.0
6	6	2.74	0.270	2.25	1.2	1.2	4.0	2.6	25	2.7	104	1.0
7	5	2.53	0.262	1.93	6.9	2.3	3.6	3.2	25	2.7	104	1.0
8	9	2.33	0.234	1.66	3.7	1.2	3.2	2.8	25	2.7	104	2.0
9	5	2.50	0.254	1.85	5.6	7.8	3.2	3.2	25	2.7	104	2.0
10	7	2.89	0.282	2.26	3.6	7.2	4.8	2.2	25	2.7	104	1.0
11	10	2.66	0.258	2.18	3.4	4.5	4.6	2.2	25	2.7	104	1.0
12	5	2.75	0.262	2.09	0.0	3.8	4.2	2.4	25	2.7	104	1.0
13	6	2.63	0.262	2.56	1.1	2.2	4.0	2.2	25	2.7	104	1.0
14	7	2.52	0.235	1.83	2.4	7.1	4.2	2.5	25	2.7	104	2.0
15	7	2.50	0.254	2.06	13.3	3.3	4.0	3.0	25	2.7	104	1.0
16	9	2.38	0.262	2.14	0.0	7.9	4.2	2.4	25	2.7	104	1.0
17	3	2.53	0.254	2.20	1.1	2.3	3.6	2.6	25	2.7	104	1.0
18	5	2.81	0.262	2.31	13.0	5.9	2.8	3.2	25	2.7	104	1.0
19	7	2.94	0.286	2.02	1.1	7.6	3.0	2.8	25	2.7	104	1.0
20	6	2.55	0.250	1.82	5.6	2.2	3.6	2.8	25	2.7	104	2.0
21	4	2.44	0.232	1.89	0.0	4.4	3.6	2.2	25	2.7	104	2.0
22	4	2.60	0.266	2.20	3.4	5.7	4.2	2.6	25	2.7	104	1.0
23	6	2.92	0.298	2.06	1.2	1.2	4.0	2.2	25	2.7	104	1.0
24	6	2.49	0.247	1.70	1.2	2.3	3.6	2.8	25	2.7	104	2.0
25	6	2.59	0.257	2.06	3.4	4.8	3.8	2.6	25	2.7	104	1.0

SITE NO. 5

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6E-3A	NON-STRESS INDEX	REL. PS SHAW
1	94.1	16300	10.0	64	14	36	17	291	134	7.15	6.85	17	59.60	53.87
2	113.8	16700	5.9	54	14	24	17	292	134	6.80	6.85	17	59.60	53.87
3	132.3	16700	0.0	56	14	26	17	208	134	7.55	6.85	17	59.60	53.87
4	64.9	17000	34.6	62	14	35	17	306	134	7.10	6.85	17	59.60	53.87
5	134.0	18600	1.8	73	14	37	17	271	134	7.65	6.85	17	59.60	53.87
6	108.0	15400	4.3	59	14	25	17	282	134	7.00	6.85	17	59.60	53.87
7	97.3	15700	8.3	73	14	33	17	294	134	7.00	6.85	17	59.60	53.87
8	86.9	18600	19.3	73	14	32	17	253	134	7.20	6.85	17	59.60	53.87
9	108.3	15400	6.5	65	14	32	17	319	134	7.45	6.85	17	59.60	53.87
10	124.8	17000	3.8	71	14	43	17	310	134	7.00	6.85	17	59.60	53.87
11	115.6	16700	2.0	68	14	34	17	250	134	7.60	6.85	17	59.60	53.87
12	99.0	16300	18.0	61	14	29	17	266	134	7.55	6.85	17	59.60	53.87
13	111.7	15700	8.3	66	14	20	17	292	134	7.05	6.85	17	59.60	53.87
14	123.5	15700	4.2	70	14	31	17	235	134	7.45	6.85	17	59.60	53.87
15	70.1	15000	23.9	61	14	32	17	226	134	7.45	6.85	17	59.60	53.87
16	65.7	15400	23.4	62	14	17	17	284	134	6.65	6.65	17	59.60	53.87
17	103.7	17600	11.1	63	14	19	17	298	134	6.75	6.85	17	59.60	53.87
18	115.2	21200	9.2	61	14	36	17	324	134	7.00	6.85	17	59.60	53.87
19	98.5	20300	17.7	71	14	30	17	348	134	6.90	6.85	17	59.60	53.87
20	97.7	16700	15.7	67	14	34	17	263	134	7.00	6.85	17	59.60	53.87
21	101.2	17000	13.5	64	14	33	17	240	134	7.65	6.85	17	59.60	53.87
22	109.4	17000	5.8	60	14	28	17	316	134	6.95	6.85	17	59.60	53.87
23	108.5	14700	0.0	62	14	26	17	200	134	7.60	6.85	17	59.60	53.87
24	128.2	18000	5.5	59	14	31	17	256	134	7.35	6.85	17	59.60	53.87
25	105.3	17000	9.6	68	14	28	17	343	134	6.80	6.85	17	59.60	53.87

SITE NO. 5(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD POT.	WEEDS 300#/UNIT
1	7	2.35	0.310	2.06	5.7	4.3	3.0	2.4	19	2.5	99	2.0
2	3	2.88	0.330	1.98	3.6	11.0	4.2	2.6	19	2.5	99	2.0
3	5	2.71	0.290	1.93	0.0	4.0	4.0	2.8	19	2.5	99	2.0
4	8	2.62	0.337	1.84	5.6	4.2	4.0	2.6	19	2.5	99	2.0
5	4	2.75	0.315	2.22	2.3	8.1	3.8	2.6	19	2.5	99	2.0
6	6	2.83	0.295	2.00	2.7	4.0	3.8	3.0	19	2.5	99	2.0
7	7	2.43	0.315	2.08	6.7	8.0	3.6	2.4	19	2.5	99	2.0
8	8	2.07	0.310	1.96	8.4	6.0	3.4	3.0	19	2.5	99	2.0
9	5	2.74	0.310	2.14	3.1	7.8	4.6	2.4	19	2.5	99	2.0
10	6	2.76	0.305	2.23	0.0	10.0	4.8	2.8	19	2.5	99	2.0
11	6	2.35	0.334	2.22	0.0	4.0	3.6	2.2	19	2.5	99	2.0
12	6	2.54	0.315	2.05	1.3	6.3	2.8	4.4	19	2.5	99	2.0
13	4	2.86	0.300	2.06	0.0	10.0	4.2	2.8	19	2.5	99	2.0
14	4	2.68	0.305	2.12	0.0	12.8	4.0	2.8	19	2.5	99	2.0
15	9	2.26	0.318	1.85	2.6	5.2	3.0	2.8	19	2.5	99	2.0
16	8	1.90	0.272	2.03	1.2	2.5	3.4	2.2	19	2.5	99	2.0
17	5	2.46	0.300	2.16	1.3	1.3	3.0	2.8	19	2.5	99	2.0
18	5	2.41	0.300	2.24	1.1	7.4	3.4	2.6	19	2.5	99	2.0
19	5	2.73	0.303	2.24	3.2	6.4	3.4	2.4	19	2.5	99	2.0
20	7	2.43	0.290	2.19	5.6	9.9	4.0	2.6	19	2.5	99	2.0
21	7	2.46	0.295	2.22	1.3	10.5	3.6	3.0	19	2.5	99	2.0
22	6	2.38	0.290	2.42	20.5	10.8	3.4	2.8	19	2.5	99	2.0
23	6	2.51	0.305	2.01	6.7	3.3	3.6	2.6	19	2.5	99	2.0
24	6	2.88	0.312	1.87	10.2	5.6	3.6	3.4	19	2.5	99	2.0
25	6	2.50	0.300	2.31	3.9	3.9	3.4	4.0	19	2.5	99	2.0

SITE NO. 6

TRT NO.	YIELD BL/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6B-3A	NON-STRESS INDEX	REL. PS SHAW
1	127.7	16700	0.0	61	10	10	6	152	72	6.45	6.90	14	61.04	57.24
2	120.6	13700	0.0	68	10	15	6	202	72	5.95	6.90	14	61.04	57.24
3	135.9	16700	0.0	74	10	15	6	393	72	6.00	6.90	14	61.04	57.24
4	128.1	17000	1.9	68	10	11	6	209	72	6.25	6.90	14	61.04	57.24
5	140.2	17300	0.0	72	10	16	6	154	72	6.05	6.90	14	61.04	57.24
6	119.4	16700	2.0	68	10	16	6	204	72	6.10	6.90	14	61.04	57.24
7	125.6	15700	2.1	66	10	12	6	154	72	6.30	6.90	14	61.04	57.24
8	107.9	17600	9.3	67	10	14	6	162	72	6.25	6.90	14	61.04	57.24
9	152.4	17600	1.9	65	10	14	6	148	72	6.10	6.90	14	61.04	57.24
10	129.8	17300	1.9	58	10	14	6	122	72	6.20	6.90	14	61.04	57.24
11	135.5	16700	3.9	76	10	19	6	277	72	5.90	6.90	14	61.04	57.24
12	135.6	16300	0.0	64	10	12	6	146	72	6.20	6.90	14	61.04	57.24
13	152.8	17000	0.0	72	10	11	6	141	72	6.60	6.90	14	61.04	57.24
14	135.8	13700	0.0	73	10	13	6	208	72	6.30	6.90	14	61.04	57.24
15	118.6	16300	0.0	67	10	18	6	175	72	6.15	6.90	14	61.04	57.24
16	115.0	17000	5.8	62	10	16	6	142	72	6.10	6.90	14	61.04	57.24
17	135.3	15700	0.0	65	10	18	6	124	72	6.20	6.90	14	61.04	57.24
18	141.0	17000	1.9	62	10	17	6	230	72	6.00	6.90	14	61.04	57.24
19	129.1	16700	0.0	68	10	15	6	162	72	6.15	6.90	14	61.04	57.24
20	140.5	16300	2.0	67	10	13	6	117	72	6.05	6.90	14	61.04	57.24
21	137.9	17000	1.9	65	10	12	6	146	72	6.20	6.90	14	61.04	57.24
22	147.5	16000	2.0	67	10	18	6	385	72	5.90	6.90	14	61.04	57.24
23	127.7	16000	2.0	67	10	14	6	351	72	6.25	6.90	14	61.04	57.24
24	136.7	18300	1.8	62	10	19	6	226	72	6.00	6.90	14	61.04	57.24
25	115.2	14000	0.0	62	10	10	6	114	72	6.15	6.90	14	61.04	57.24

SITE NO. 6(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD POT.	WEEDS 300#/UNIT
1	2	2.64	0.262	1.51	0.0	2.8	0.0	0.0	14	0.8	95	1.0
2	1	2.65	0.290	1.67	0.0	10.0	0.0	0.0	14	0.8	95	1.0
3	-2	2.65	0.270	2.27	0.0	4.2	0.0	0.0	14	0.8	95	1.0
4	3	2.43	0.266	2.04	0.0	2.8	0.0	0.0	14	0.8	95	1.0
5	1	2.66	0.300	2.10	0.0	8.2	0.0	0.0	14	0.8	95	1.0
6	2	2.72	0.280	1.55	0.0	6.8	0.0	0.0	14	0.8	95	1.0
7	2	2.66	0.280	1.62	0.0	4.5	0.0	0.0	14	0.8	95	1.0
8	4	2.52	0.266	1.90	0.0	2.7	0.0	0.0	14	0.8	95	1.0
9	-1	2.85	0.290	1.95	0.0	6.6	0.0	0.0	14	0.8	95	1.0
10	2	2.78	0.270	1.69	0.0	0.0	0.0	0.0	14	0.8	95	1.0
11	-1	2.70	0.280	1.84	0.0	4.2	0.0	0.0	14	0.8	95	1.0
12	2	2.67	0.270	1.82	0.0	2.7	0.0	0.0	14	0.8	95	1.0
13	-1	2.71	0.300	1.84	0.0	11.1	0.0	0.0	14	0.8	95	1.0
14	-3	2.67	0.295	2.00	0.0	3.2	0.0	0.0	14	0.8	95	1.0
15	2	2.44	0.260	1.87	0.0	2.9	0.0	0.0	14	0.8	95	1.0
16	4	2.52	0.275	1.64	0.0	2.7	0.0	0.0	14	0.8	95	1.0
17	2	2.72	0.280	1.76	0.0	0.0	0.0	0.0	14	0.8	95	1.0
18	-1	2.72	0.280	1.97	0.0	9.7	0.0	0.0	14	0.8	95	1.0
19	3	2.55	0.270	1.86	0.0	0.0	0.0	0.0	14	0.8	95	1.0
20	2	2.61	0.270	1.65	0.0	4.2	0.0	0.0	14	0.8	95	1.0
21	1	2.70	0.270	1.91	0.0	4.3	0.0	0.0	14	0.8	95	1.0
22	1	2.54	0.270	2.33	0.0	4.5	0.0	0.0	14	0.8	95	1.0
23	1	2.86	0.293	2.08	0.0	8.7	0.0	0.0	14	0.8	95	1.0
24	-1	2.63	0.265	1.96	0.0	7.5	0.0	0.0	14	0.8	95	1.0
25	3	2.59	0.280	1.96	0.0	15.5	0.0	0.0	14	0.8	95	1.0

SITE NO. 9

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6B-5A	NON-STRESS INDEX	REL. PS SHAW
1	80.6	15600	7.0	58	11	12	6	187	76	6.65	6.80	12	60.24	55.01
2	116.2	14500	0.0	54	11	8	6	174	76	6.70	6.80	12	60.24	55.01
3	95.1	15200	0.0	54	11	10	6	188	76	6.75	6.80	12	60.24	55.01
4	71.7	14900	4.9	62	11	10	6	192	76	6.65	6.80	12	60.24	55.01
5	124.9	15600	4.7	60	11	12	6	173	76	7.00	6.80	12	60.24	55.01
6	99.1	16000	4.5	61	11	10	6	194	76	6.70	6.80	12	60.24	55.01
7	91.4	12300	2.9	55	11	12	6	168	76	7.00	6.80	12	60.24	55.01
8	60.8	16000	13.6	50	11	10	6	177	76	6.60	6.80	12	60.24	55.01
9	94.6	16000	4.5	58	11	16	6	216	76	6.65	6.80	12	60.24	55.01
10	90.4	12700	0.0	49	11	11	6	173	76	6.65	6.80	12	60.24	55.01
11	99.5	15600	2.3	55	11	9	6	154	76	6.55	6.80	12	60.24	55.01
12	87.8	11200	3.2	57	11	12	6	156	76	6.90	6.80	12	60.24	55.01
13	102.3	11600	0.0	62	11	10	6	202	76	6.70	6.80	12	60.24	55.01
14	117.2	14200	0.0	52	11	12	6	186	76	6.90	6.80	12	60.24	55.01
15	72.0	15200	2.4	50	11	14	6	238	76	6.50	6.80	12	60.24	55.01
16	88.0	15600	4.7	48	11	10	6	174	76	6.70	6.80	12	60.24	55.01
17	110.5	14500	5.0	57	11	15	6	194	76	6.70	6.80	12	60.24	55.01
18	109.2	14500	2.5	58	11	12	6	174	76	6.70	6.80	12	60.24	55.01
19	75.1	13400	0.0	56	11	12	6	212	76	6.45	6.80	12	60.24	55.01
20	90.9	13800	7.9	56	11	12	6	170	76	6.65	6.80	12	60.24	55.01
21	93.8	11200	3.2	60	11	14	6	219	76	7.00	6.80	12	60.24	55.01
22	95.7	13400	2.7	56	11	16	6	209	76	6.55	6.80	12	60.24	55.01
23	115.9	15600	0.0	68	11	12	6	213	76	6.60	6.80	12	60.24	55.01
24	113.0	17100	2.1	57	11	10	6	185	76	6.70	6.80	12	60.24	55.01
25	111.6	14500	0.0	56	11	10	6	170	76	6.60	6.80	12	60.24	55.01

SITE NO. 9(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD POT.	WEEDS 300#/UNIT
1	2	2.52	0.230	1.71	0.0	1.7	0.0	0.0	18	1.7	95	4.0
2	-3	2.62	0.260	1.46	0.0	6.8	0.0	0.0	18	1.7	95	4.0
3	2	2.89	0.253	2.10	0.0	5.4	0.0	0.0	18	1.7	95	4.0
4	2	2.36	0.234	1.78	0.0	5.1	0.0	0.0	18	1.7	95	4.0
5	-3	2.65	0.270	2.08	0.0	17.2	0.0	0.0	18	1.7	95	4.0
6	3	2.62	0.244	1.78	0.0	7.2	0.0	0.0	18	1.7	95	4.0
7	2	2.62	0.262	1.80	0.0	3.9	0.0	0.0	18	1.7	95	4.0
8	7	2.30	0.254	2.09	0.0	12.7	0.0	0.0	18	1.7	95	4.0
9	-2	2.59	0.254	2.14	0.0	23.3	0.0	0.0	18	1.7	95	4.0
10	2	2.88	0.250	1.63	0.0	10.0	0.0	0.0	18	1.7	95	4.0
11	1	2.45	0.247	2.12	0.0	7.6	0.0	0.0	18	1.7	95	4.0
12	2	2.85	0.247	1.62	0.0	6.1	0.0	0.0	18	1.7	95	4.0
13	-3	2.72	0.254	1.80	0.0	6.2	0.0	0.0	18	1.7	95	4.0
14	-3	2.75	0.262	1.90	0.0	3.8	0.0	0.0	18	1.7	95	4.0
15	2	2.53	0.247	1.88	0.0	6.2	0.0	0.0	18	1.7	95	4.0
16	-1	2.28	0.247	2.07	0.0	10.2	0.0	0.0	18	1.7	95	4.0
17	5	2.73	0.262	2.08	0.0	9.0	0.0	0.0	18	1.7	95	4.0
18	-2	2.82	0.262	1.66	0.0	5.1	0.0	0.0	18	1.7	95	4.0
19	-1	2.72	0.244	2.00	0.0	21.2	0.0	0.0	18	1.7	95	4.0
20	2	2.76	0.247	1.86	0.0	7.1	0.0	0.0	18	1.7	95	4.0
21	2	2.77	0.247	1.90	0.0	7.3	0.0	0.0	18	1.7	95	4.0
22	1	2.54	0.247	2.15	0.0	14.9	0.0	0.0	18	1.7	95	4.0
23	1	2.58	0.254	1.70	0.0	18.3	0.0	0.0	18	1.7	95	4.0
24	1	2.70	0.261	1.72	0.0	4.3	0.0	0.0	18	1.7	95	4.0
25	1	2.51	0.247	1.87	0.0	1.9	0.0	0.0	18	1.7	95	4.0

SITE NO. 11

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 60-3A	NON-STRESS INDEX	REL. PS SHAW
1	111.9	19900	6.6	95	16	14	10	197	80	6.35	6.55	33	51.32	39.72
2	116.0	16000	8.2	72	16	14	10	151	80	6.20	6.55	33	51.32	39.72
3	119.2	18000	3.6	96	16	13	10	198	80	6.25	6.55	33	51.32	39.72
4	121.7	17300	5.7	84	16	12	10	210	80	6.45	6.55	33	51.32	39.72
5	96.5	18600	14.0	78	16	13	10	188	80	6.45	6.55	33	51.32	39.72
6	124.6	18900	5.2	82	16	19	10	180	80	6.40	6.55	33	51.32	39.72
7	118.3	17000	3.8	98	16	14	10	207	80	6.30	6.55	33	51.32	39.72
8	115.5	16300	4.0	94	16	16	10	238	80	6.45	6.55	33	51.32	39.72
9	92.4	15000	13.0	87	16	16	10	197	80	6.40	6.55	33	51.32	39.72
10	126.8	18000	0.0	96	16	12	10	186	80	6.35	6.55	33	51.32	39.72
11	132.9	16300	4.0	86	16	14	10	208	80	6.35	6.55	33	51.32	39.72
12	107.5	16700	7.8	96	16	12	10	166	80	6.45	6.55	33	51.32	39.72
13	111.3	17300	9.4	100	16	15	10	192	80	6.35	6.55	33	51.32	39.72
14	125.3	18000	5.5	90	16	16	10	202	80	6.40	6.55	32	51.32	39.72
15	116.0	18300	8.9	97	16	14	10	185	80	6.40	6.55	33	51.32	39.72
16	113.3	18000	3.6	79	16	15	10	227	80	6.35	6.55	33	51.32	39.72
17	91.9	17000	15.4	95	16	14	10	212	80	6.40	6.55	33	51.32	39.72
18	108.6	18500	10.3	94	16	16	10	191	80	6.60	6.55	33	51.32	39.72
19	119.3	18600	10.5	100	16	14	10	231	80	6.50	6.55	33	51.32	39.72
20	126.2	17000	1.9	92	16	16	10	192	80	6.45	6.55	33	51.32	39.72
21	96.0	16000	8.2	96	16	15	10	228	80	6.45	6.55	33	51.32	39.72
22	130.3	18000	7.3	93	16	12	10	232	80	6.35	6.55	33	51.32	39.72
23	116.8	17600	7.4	84	16	15	10	242	80	6.45	6.55	33	51.32	39.72
24	120.2	17600	2.7	86	16	13	10	189	80	6.40	6.55	33	51.32	39.72
25	115.1	17500	7.0	90	16	15	10	202	80	6.40	6.55	33	51.32	39.72

SITE NO. 11(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD PCT.	WEEDS 300#/UNIT
1	8	2.59	0.254	1.95	4.6	6.9	0.0	0.0	18	1.0	104	1.0
2	6	2.97	0.290	1.75	4.2	11.3	0.0	0.0	18	1.0	104	1.0
3	8	2.76	0.262	2.10	7.6	6.3	0.0	0.0	18	1.0	104	1.0
4	6	2.72	0.270	2.14	1.3	2.5	0.0	0.0	18	1.0	104	1.0
5	8	2.81	0.262	2.02	8.0	9.1	0.0	0.0	18	1.0	104	3.0
6	7	2.90	0.270	1.86	2.4	6.0	0.0	0.0	18	1.0	104	1.0
7	7	2.78	0.290	2.18	9.3	9.3	0.0	0.0	18	1.0	104	1.0
8	6	2.66	0.266	2.04	19.0	6.3	0.0	0.0	18	1.0	104	1.0
9	7	2.59	0.270	1.92	5.2	9.6	0.0	0.0	18	1.0	104	3.0
10	7	2.92	0.270	2.22	3.8	1.3	0.0	0.0	18	1.0	104	1.0
11	5	2.79	0.290	2.18	2.8	4.1	0.0	0.0	18	1.0	104	1.0
12	7	2.73	0.254	1.96	6.4	14.1	0.0	0.0	18	1.0	104	2.0
13	6	2.71	0.270	2.08	2.6	11.8	0.0	0.0	18	1.0	104	1.0
14	6	2.79	0.262	2.17	6.4	11.6	0.0	0.0	18	1.0	104	1.0
15	6	2.72	0.270	2.05	3.5	3.5	0.0	0.0	18	1.0	104	1.0
16	6	2.59	0.270	2.24	14.3	9.1	0.0	0.0	18	1.0	104	1.0
17	8	2.64	0.270	1.88	10.9	13.8	0.0	0.0	18	1.0	104	3.0
18	4	2.68	0.270	2.21	1.2	7.4	0.0	0.0	18	1.0	104	1.0
19	7	2.67	0.270	2.18	8.0	2.3	0.0	0.0	18	1.0	104	1.0
20	7	2.83	0.262	2.10	5.2	10.6	0.0	0.0	18	1.0	104	1.0
21	9	2.61	0.270	2.04	2.8	9.5	0.0	0.0	18	1.0	104	3.0
22	7	2.90	0.280	2.16	5.1	3.8	0.0	0.0	18	1.0	104	1.0
23	7	2.85	0.270	1.92	11.3	7.4	0.0	0.0	18	1.0	104	1.0
24	6	2.84	0.280	1.95	9.0	12.5	0.0	0.0	18	1.0	104	1.0
25	6	2.77	0.270	2.05	6.5	7.9	0.0	0.0	18	1.0	104	1.0

SITE NO. 12

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6B-3A	NON-STRESS INDEX	REL. PS SHAW
1	94.2	12400	5.3	65	10	18	7	216	98	6.50	6.45	31	54.32	43.53
2	114.7	13100	5.0	64	10	23	7	232	98	6.60	6.45	31	54.32	43.53
3	101.6	13700	4.8	62	10	16	7	194	98	6.60	6.45	31	54.32	43.53
4	95.7	10800	0.0	69	10	18	7	217	98	6.35	6.45	31	54.32	43.53
5	127.4	13100	0.0	62	10	17	7	218	98	6.50	6.45	31	54.32	43.53
6	113.0	14000	0.0	55	10	22	7	223	98	6.20	6.45	31	54.32	43.53
7	105.4	11110	2.9	55	10	15	7	234	98	6.50	6.45	31	54.32	43.53
8	104.5	13700	2.4	60	10	24	7	220	98	6.55	6.45	31	54.32	43.53
9	112.3	11800	0.0	63	10	22	7	206	98	6.40	6.45	31	54.32	43.53
10	106.9	13400	7.3	56	10	14	7	208	98	6.55	6.45	31	54.32	43.53
11	110.9	11800	0.0	65	10	20	7	220	98	6.25	6.45	31	54.32	43.53
12	83.4	12700	2.6	60	10	22	7	224	98	6.55	6.45	31	54.32	43.53
13	96.8	12100	5.4	66	10	17	7	258	98	6.30	6.45	31	54.32	43.53
14	107.8	12700	0.0	60	10	19	7	250	98	6.60	6.45	31	54.32	43.53
15	93.7	10500	3.1	59	10	21	7	221	98	6.25	6.45	31	54.32	43.53
16	78.0	11400	5.7	56	10	22	7	232	98	6.50	6.45	31	54.32	43.53
17	120.3	13100	2.5	64	10	20	7	236	98	6.45	6.45	31	54.32	43.53
18	112.5	12400	0.0	46	10	18	7	217	98	6.50	6.45	31	54.32	43.53
19	113.1	12700	2.6	61	10	26	7	232	98	6.35	6.45	31	54.32	43.53
20	105.7	13100	0.0	62	10	22	7	229	98	6.25	6.45	31	54.32	43.53
21	123.0	13100	2.5	52	10	15	7	234	98	6.35	6.45	31	54.32	43.53
22	107.6	11800	2.8	47	10	32	7	230	98	6.45	6.45	31	54.32	43.53
23	97.8	14000	4.7	56	10	23	7	239	98	6.35	6.45	31	54.32	43.53
24	114.8	13100	2.5	48	10	16	7	232	98	6.55	6.45	31	54.32	43.53
25	102.1	11100	0.0	49	10	16	7	248	98	6.40	6.45	31	54.32	43.53

SITE NO. 12(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAMAGE	PLANT. DATE MAY1=1	PAST CROPPING	SOIL YIELD PCT.	WEEDS 300#/UNIT
1	-1	2.82	0.270	1.65	0.0	31.4	2.6	5.0	11	2.7	95	1.0
2	-3	2.68	0.258	1.62	5.2	25.9	3.2	4.0	11	2.7	95	1.0
3	1	2.67	0.243	1.96	1.8	30.4	3.8	3.6	11	2.7	95	1.0
4	-2	2.88	0.260	1.85	0.0	20.8	3.2	4.2	11	2.7	95	1.0
5	-4	2.74	0.290	2.10	10.7	26.8	3.6	4.2	11	2.7	95	1.0
6	-2	2.67	0.245	1.49	0.0	22.9	3.6	3.2	11	2.7	95	1.0
7	-3	2.64	0.282	1.60	0.0	12.8	4.0	4.2	11	2.7	95	1.0
8	1	2.61	0.258	1.75	5.3	26.3	3.4	4.2	11	2.7	95	1.0
9	-7	2.74	0.280	1.86	3.7	27.8	4.4	2.8	11	2.7	95	1.0
10	-3	2.67	0.278	1.95	5.1	11.9	4.8	2.2	11	2.7	95	1.0
11	-3	2.65	0.280	2.00	0.0	19.2	5.0	2.0	11	2.7	95	1.0
12	2	2.26	0.262	1.86	0.0	21.7	1.8	5.4	11	2.7	95	1.0
13	-2	2.66	0.255	1.64	0.0	25.4	4.0	4.4	11	2.7	95	1.0
14	4	2.58	0.271	1.92	4.8	17.5	4.2	3.4	11	2.7	95	1.0
15	-8	2.62	0.281	1.88	0.0	27.7	4.0	3.8	11	2.7	95	1.0
16	3	2.17	0.261	1.76	4.3	23.4	2.6	5.4	11	2.7	95	1.0
17	-6	2.71	0.280	2.04	0.0	31.5	3.6	3.2	11	2.7	95	1.0
18	-2	2.65	0.290	2.10	0.0	13.1	4.4	3.0	11	2.7	95	1.0
19	-1	2.65	0.262	2.06	3.4	32.2	3.0	4.4	11	2.7	95	1.0
20	-3	2.63	0.262	1.78	0.0	15.0	4.4	2.6	11	2.7	95	1.0
21	-3	2.59	0.262	1.80	0.0	33.4	3.0	4.6	11	2.7	95	1.0
22	-4	2.72	0.284	2.03	3.6	21.8	4.0	3.2	11	2.7	95	1.0
23	4	2.70	0.270	1.83	3.2	33.9	2.2	4.8	11	2.7	95	1.0
24	-3	2.72	0.285	1.66	0.0	22.9	4.0	3.8	11	2.7	95	1.0
25	-2	2.28	0.270	2.12	10.9	32.6	2.0	5.6	11	2.7	95	1.0

SITE NO. 17

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6E-3A	NON-STRESS INDEX	REL. PS SHAW
1	98.9	11800	0.0	77	9	20	6	187	70	6.70	7.75	29	54.88	43.73
2	120.5	14700	2.2	71	9	38	6	188	70	7.90	7.75	29	54.88	43.73
3	104.5	13700	9.5	69	9	31	6	145	70	7.85	7.75	29	54.88	43.73
4	118.6	16000	14.3	82	9	17	6	215	70	6.65	7.75	29	54.88	43.73
5	113.4	16300	6.0	68	9	17	6	125	70	6.80	7.75	29	54.88	43.73
6	111.6	12100	2.7	71	9	13	6	166	70	8.00	7.75	29	54.88	43.73
7	83.8	12700	10.2	64	9	28	6	145	70	6.90	7.75	29	54.88	43.73
8	81.9	10800	6.1	69	9	2	6	168	70	8.05	7.75	29	54.88	43.73
9	111.7	10800	3.0	57	9	10	6	152	70	8.00	7.75	29	54.88	43.73
10	123.3	15000	8.7	73	9	26	6	220	70	6.55	7.75	29	54.88	43.73
11	118.8	16300	4.0	76	9	19	6	178	70	6.70	7.75	29	54.88	43.73
12	91.5	12100	8.1	64	9	26	6	115	70	7.95	7.75	29	54.88	43.73
13	119.4	15700	6.2	66	9	40	6	154	70	6.70	7.75	29	54.88	43.73
14	120.3	12700	10.2	72	9	31	6	159	70	6.60	7.75	29	54.88	43.73
15	87.9	12100	5.4	71	9	15	6	215	70	8.10	7.75	29	54.88	43.73
16	76.3	13400	19.5	62	9	31	6	153	70	6.60	7.75	29	54.88	43.73
17	119.9	12700	0.0	77	9	22	6	216	70	6.60	7.75	29	54.88	43.73
18	92.5	11100	2.9	55	9	3	6	153	70	8.05	7.75	29	54.88	43.73
19	95.7	14400	9.1	73	9	29	6	187	70	6.60	7.75	29	54.88	43.73
20	126.7	13100	5.0	84	9	66	6	146	70	6.70	7.75	29	54.88	43.73
21	131.3	16000	4.1	78	9	24	6	208	70	6.60	7.75	29	54.88	43.73
22	115.3	16000	6.1	78	9	26	6	160	70	7.55	7.75	29	54.88	43.73
23	108.8	14000	11.6	81	9	22	6	152	70	7.20	7.75	29	54.88	43.73
24	140.4	15400	2.1	69	9	15	6	210	70	6.65	7.75	29	54.88	43.73
25	105.3	13400	2.4	81	9	45	6	150	70	7.55	7.75	29	54.88	43.73

SITE NO. 17(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD POT.	WEEDS 300#/ UNIT
1	4	2.61	0.282	1.52	3.9	7.8	0.0	0.0	9	3.7	90	1.0
2	3	3.01	0.273	1.19	0.0	12.7	0.0	0.0	9	3.7	83	1.0
3	7	2.70	0.263	1.46	1.7	35.5	0.0	0.0	9	3.7	83	1.0
4	4	2.47	0.262	1.79	5.6	4.2	0.0	0.0	9	3.7	90	1.0
5	3	2.74	0.274	1.42	4.1	21.9	0.0	0.0	9	3.7	90	1.0
6	5	2.89	0.271	1.50	0.0	5.6	0.0	0.0	9	3.7	83	1.0
7	5	2.73	0.301	1.60	5.6	3.7	0.0	0.0	9	3.7	90	1.0
8	5	2.86	0.262	1.89	0.0	5.0	0.0	0.0	9	3.7	83	1.0
9	5	2.94	0.323	1.30	0.0	8.7	0.0	0.0	9	3.7	83	1.0
10	3	2.85	0.252	2.00	8.6	14.4	0.0	0.0	9	3.7	90	1.0
11	-1	2.68	0.278	1.50	4.3	24.6	0.0	0.0	9	3.7	90	1.0
12	7	2.77	0.257	1.34	1.8	10.9	0.0	0.0	9	3.7	83	1.0
13	4	2.77	0.263	1.28	11.4	20.0	0.0	0.0	9	3.7	90	1.0
14	1	2.73	0.280	1.57	9.6	21.2	0.0	0.0	9	3.7	90	1.0
15	8	2.55	0.281	1.62	0.0	13.8	0.0	0.0	9	3.7	83	1.0
16	7	2.65	0.302	1.63	8.0	11.3	0.0	0.0	9	3.7	90	1.0
17	2	2.85	0.277	1.79	4.0	12.0	0.0	0.0	9	3.7	90	1.0
18	7	2.68	0.288	1.46	4.5	13.7	0.0	0.0	9	3.7	83	1.0
19	5	2.82	0.262	1.48	3.0	12.1	0.0	0.0	9	3.7	90	1.0
20	2	2.90	0.290	1.45	0.0	15.8	0.0	0.0	9	3.7	90	1.0
21	1	2.79	0.246	1.66	7.0	15.5	0.0	0.0	9	3.7	90	1.0
22	4	2.68	0.251	1.47	1.5	20.9	0.0	0.0	9	3.7	83	1.0
23	4	2.71	0.253	1.25	16.9	16.9	0.0	0.0	9	3.7	83	1.0
24	1	2.70	0.255	1.69	1.4	13.0	0.0	0.0	9	3.7	90	1.0
25	3	2.60	0.282	1.35	0.0	25.4	0.0	0.0	9	3.7	83	1.0

SITE NO. 20

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6B-3A	NON-STRESS INDEX	REL. PS SHAW
1	53.6	21500	31.6	64	12	51	16	259	137	6.45	6.75	56	33.50	6.79
2	73.6	21700	28.6	56	12	26	16	252	137	6.50	6.75	56	33.50	6.79
3	59.4	22000	32.8	54	12	38	16	252	137	6.60	6.75	56	33.50	6.79
4	39.3	21700	33.3	67	12	46	16	287	137	6.20	6.75	56	33.50	6.79
5	28.2	21700	57.1	62	12	35	16	253	137	6.90	6.75	56	33.50	6.79
6	44.6	26800	43.6	58	12	51	16	311	137	6.65	6.75	56	33.50	6.79
7	58.4	21000	36.1	61	12	37	16	284	137	6.60	6.75	56	33.50	6.79
8	70.7	22000	29.7	52	12	28	16	282	137	6.80	6.75	56	33.50	6.79
9	42.7	25100	54.8	64	12	38	16	293	137	6.55	6.75	56	33.50	6.79
10	48.2	19300	44.6	63	12	30	16	278	137	6.85	6.75	56	33.50	6.79
11	51.5	21000	29.5	74	12	34	16	310	137	6.65	6.75	56	33.50	6.79
12	27.4	23700	56.5	64	12	36	16	350	137	6.80	6.75	56	33.50	6.79
13	48.7	20300	30.5	63	12	45	16	403	137	6.80	6.75	56	33.50	6.79
14	62.5	23000	26.9	58	12	18	16	225	137	6.50	6.75	56	33.50	6.79
15	60.2	18600	24.1	66	12	26	16	252	137	6.20	6.75	56	33.50	6.79
16	32.4	20600	45.0	73	12	37	16	342	137	6.60	6.75	56	33.50	6.79
17	79.8	25800	24.0	63	12	35	16	267	137	6.25	6.75	56	33.50	6.79
18	45.6	17900	32.7	78	12	56	16	268	137	6.80	6.75	56	33.50	6.79
19	39.2	22400	44.6	58	12	30	16	240	137	6.40	6.75	56	33.50	6.79
20	55.4	19600	29.8	62	12	39	16	282	137	6.60	6.75	56	33.50	6.79
21	61.9	23400	38.2	63	12	20	16	228	137	6.80	6.75	56	33.50	6.79
22	34.3	20600	44.8	66	12	40	16	315	137	6.70	6.75	56	33.50	6.79
23	35.0	18900	38.2	68	12	50	16	298	137	6.60	6.75	56	33.50	6.79
24	38.9	21000	44.3	53	12	31	16	235	137	6.50	6.75	56	33.50	6.79
25	59.2	20450	32.2	62	12	32	16	267	137	6.55	6.75	56	33.50	6.79

SITE NO. 20(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD PCT.	WEEDS 300#/ UNIT
1	2	2.70	0.251	2.63	0.0	0.0	3.2	1.9	6	3.0	107	0.0
2	1	2.87	0.282	2.96	0.0	2.1	4.6	1.6	6	3.0	107	0.0
3	6	2.63	0.239	2.58	0.0	0.0	3.6	1.8	6	3.0	107	0.0
4	1	2.55	0.261	3.02	0.0	0.0	3.4	1.8	6	3.0	107	0.0
5	4	2.83	0.279	2.78	0.0	0.0	3.2	2.2	6	3.0	107	0.0
6	2	2.80	0.258	2.70	1.0	2.0	2.8	1.8	6	3.0	107	0.0
7	2	2.62	0.282	2.60	0.0	0.0	4.0	2.0	6	3.0	107	0.0
8	3	2.40	0.232	2.84	0.0	2.0	4.2	1.8	6	3.0	107	0.0
9	5	2.65	0.268	2.78	0.0	0.0	3.0	1.6	6	3.0	107	0.0
10	4	2.75	0.258	2.74	0.0	1.0	3.6	2.0	6	3.0	107	0.0
11	1	2.65	0.256	2.88	0.0	0.0	3.6	1.6	6	3.0	107	0.0
12	4	2.68	0.284	2.80	0.0	0.0	3.4	1.8	6	3.0	107	0.0
13	-1	2.88	0.297	2.64	0.0	0.0	3.6	2.2	6	3.0	107	0.0
14	3	2.65	0.268	2.66	0.0	0.0	3.2	1.4	6	3.0	107	0.0
15	3	2.53	0.252	2.58	1.1	1.1	3.6	2.4	6	3.0	107	0.0
16	1	2.46	0.247	2.62	0.0	2.4	3.8	1.8	6	3.0	107	0.0
17	1	2.81	0.280	2.78	0.0	0.0	3.6	1.6	6	3.0	107	0.0
18	3	2.73	0.307	2.90	0.0	2.2	3.6	2.0	6	3.0	107	0.0
19	3	2.81	0.280	2.56	0.0	0.0	2.8	1.2	6	3.0	107	0.0
20	1	2.82	0.284	2.76	0.0	1.1	3.4	1.8	6	3.0	107	0.0
21	3	2.74	0.265	2.70	0.0	0.0	3.2	1.8	6	3.0	107	0.0
22	3	2.75	0.288	2.73	0.0	0.0	3.4	2.2	6	3.0	107	0.0
23	3	2.85	0.298	2.33	0.0	0.0	2.8	2.0	6	3.0	107	0.0
24	4	2.74	0.270	2.69	0.0	1.0	3.6	1.6	6	3.0	107	0.0
25	2	2.94	0.286	2.82	0.0	0.6	3.4	1.8	6	3.0	107	0.0

SITE NO. 21

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6B-3A	NON-STRESS INDEX	REL. PS SHAW
1	85.3	16600	3.0	51	28	34	24	288	212	6.05	5.95	51	35.46	14.51
2	85.2	16700	5.9	57	28	37	24	311	212	6.10	5.95	51	35.46	14.51
3	76.2	17300	7.5	62	28	31	24	340	212	6.20	5.95	51	35.46	14.51
4	83.6	18000	12.7	53	28	38	24	302	212	6.10	5.95	51	35.46	14.51
5	70.0	18300	8.9	50	28	42	24	270	212	6.10	5.95	51	35.46	14.51
6	89.1	18300	7.1	56	28	44	24	326	212	6.10	5.95	51	35.46	14.51
7	63.8	16700	2.0	59	28	31	24	277	212	6.20	5.95	51	35.46	14.51
8	88.6	16700	0.0	57	28	34	24	308	212	6.10	5.95	51	35.46	14.51
9	55.3	17000	9.6	55	28	48	24	246	212	6.10	5.95	51	35.46	14.51
10	84.4	17000	0.0	60	28	35	24	302	212	6.00	5.95	51	35.46	14.51
11	84.2	14400	9.1	53	28	40	24	305	212	6.00	5.95	51	35.46	14.51
12	65.2	13100	7.5	52	28	32	24	342	212	6.20	5.95	51	35.46	14.51
13	90.3	15700	15.4	58	28	34	24	309	212	6.05	5.95	51	35.46	14.51
14	60.7	18300	12.5	62	28	45	24	331	212	6.05	5.95	51	35.46	14.51
15	63.4	15400	12.8	62	28	42	24	327	212	6.25	5.95	51	35.46	14.51
16	68.0	14400	15.9	52	28	36	24	306	212	5.95	5.95	51	35.46	14.51
17	76.9	15400	2.1	64	28	36	24	307	212	6.10	5.95	51	35.46	14.51
18	83.0	17100	2.1	52	28	30	24	293	212	6.20	5.95	51	35.46	14.51
19	55.3	18900	10.3	46	28	36	24	319	212	6.15	5.95	51	35.46	14.51
20	59.7	18000	12.7	48	28	38	24	354	212	5.90	5.95	51	35.46	14.51
21	59.3	18000	23.6	53	28	44	24	390	212	6.20	5.95	51	35.46	14.51
22	80.0	16700	5.9	54	28	42	24	291	212	6.10	5.95	51	35.46	14.51
23	60.3	19900	13.1	57	28	45	24	327	212	6.10	5.95	51	35.46	14.51
24	94.3	22500	7.2	61	28	46	24	370	212	6.00	5.95	51	35.46	14.51
25	59.5	17300	13.1	60	28	36	24	308	212	6.10	5.95	51	35.46	14.51

SITE NO. 21(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD PCT.	WEEDS 300#/UNIT
1	-4	2.52	0.238	2.20	0.0	1.4	3.9	1.7	9	4.0	109	1.0
2	-4	2.85	0.258	2.20	0.0	1.3	2.8	1.6	9	4.0	109	1.0
3	-2	3.02	0.273	2.62	0.0	0.0	3.2	2.2	9	4.0	109	1.0
4	-5	2.40	0.236	2.42	0.0	0.0	3.2	2.0	9	4.0	109	1.0
5	-4	2.63	0.248	2.52	0.0	0.0	2.4	2.0	9	4.0	109	1.0
6	-4	2.74	0.247	2.40	0.0	0.0	3.4	1.8	9	4.0	109	1.0
7	-3	2.34	0.230	1.92	0.0	1.3	4.0	2.0	9	4.0	109	1.0
8	-4	2.73	0.229	2.47	0.0	1.4	3.6	1.8	9	4.0	109	1.0
9	-4	2.87	0.260	2.56	0.0	1.4	3.0	1.8	9	4.0	109	1.0
10	-4	2.62	0.247	2.29	0.0	2.5	3.6	1.8	9	4.0	109	1.0
11	-5	2.77	0.268	2.22	0.0	0.0	4.0	1.8	9	4.0	109	1.0
12	-3	2.72	0.273	2.38	0.0	0.0	4.6	1.8	9	4.0	109	1.0
13	-5	2.89	0.251	2.54	0.0	0.0	3.6	1.8	9	4.0	109	1.0
14	-3	2.88	0.262	2.38	0.0	1.2	3.4	1.6	9	4.0	109	1.0
15	-3	2.65	0.261	2.50	0.0	0.0	3.6	1.6	9	4.0	109	1.0
16	-5	2.63	0.258	2.45	0.0	1.2	3.6	1.8	9	4.0	109	1.0
17	-4	2.82	0.275	2.52	0.0	0.0	3.4	1.6	9	4.0	109	1.0
18	-4	2.72	0.256	2.52	0.0	0.0	2.8	1.6	9	4.0	109	1.0
19	-3	2.68	0.240	2.28	0.0	0.0	2.6	1.8	9	4.0	109	1.0
20	-4	2.83	0.268	2.28	0.0	12.7	3.0	1.8	9	4.0	109	1.0
21	-3	2.66	0.250	2.62	0.0	1.2	3.6	2.0	9	4.0	109	1.0
22	-4	2.78	0.280	2.64	0.0	0.0	3.6	2.0	9	4.0	109	1.0
23	-4	2.81	0.257	2.48	0.0	0.0	3.4	1.8	9	4.0	109	1.0
24	-5	2.62	0.248	2.34	0.0	1.4	3.6	2.0	9	4.0	109	1.0
25	-3	2.79	0.254	2.47	0.0	0.0	3.3	1.8	9	4.0	109	1.0

SITE NO. 22

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6B-3A	NON-STRESS INDEX	REL. PS SHAW
1	81.6	14400	5.6	70	16	99	26	385	152	6.00	6.40	47	41.38	19.81
2	99.5	16700	3.9	68	16	98	26	432	152	6.85	6.40	47	41.38	19.81
3	90.8	15700	6.2	98	16	114	26	430	152	5.85	6.40	47	41.38	19.81
4	57.4	16700	21.6	58	16	126	26	459	152	5.75	6.40	47	41.38	19.81
5	90.7	17300	7.5	74	16	74	26	358	152	6.20	6.40	47	41.38	19.81
6	123.7	17600	5.6	66	16	78	26	309	152	6.30	6.40	47	41.38	19.81
7	100.2	17300	3.8	62	16	80	26	426	152	5.90	6.40	47	41.38	19.81
8	92.7	16000	12.2	92	16	59	26	379	152	6.10	6.40	47	41.38	19.81
9	95.8	15400	2.1	72	16	150	26	434	152	6.10	6.40	47	41.38	19.81
10	95.2	17600	7.4	69	16	68	26	336	152	6.00	6.40	47	41.38	19.81
11	96.2	17300	7.5	61	16	65	26	340	152	5.90	6.40	47	41.38	19.81
12	86.5	16700	9.8	105	16	88	26	453	152	6.15	6.40	47	41.38	19.81
13	70.7	16700	9.8	60	16	91	26	475	152	5.90	6.40	47	41.38	19.81
14	90.6	16000	6.1	72	16	124	26	494	152	5.95	6.40	47	41.38	19.81
15	77.8	19900	6.6	76	16	66	26	242	152	6.05	6.40	47	41.38	19.81
16	63.5	17600	16.7	83	16	100	26	422	152	6.00	6.40	47	41.38	19.81
17	82.6	16000	6.1	94	16	90	26	482	152	5.80	6.40	47	41.38	19.81
18	81.7	17300	7.5	72	16	65	26	430	152	5.75	6.40	47	41.38	19.81
19	86.8	15700	6.2	74	16	96	26	469	152	6.00	6.40	47	41.38	19.81
20	76.7	15400	8.5	78	16	125	26	432	152	5.80	6.40	47	41.38	19.81
21	81.6	16000	8.2	76	16	76	26	369	152	5.65	6.40	47	41.38	19.81
22	76.7	17300	11.3	71	16	57	26	338	152	5.95	6.40	47	41.38	19.81
23	56.4	18000	14.5	91	16	117	26	561	152	5.90	6.40	47	41.38	19.81
24	97.2	16700	5.9	89	16	103	26	360	152	6.00	6.40	47	41.38	19.81
25	86.3	16500	8.9	65	16	80	26	317	152	6.00	6.40	47	41.38	19.81

SITE NO. 22(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD POT.	WEEDS 000#/UNIT
1	-6	2.60	0.266	2.49	0.0	8.2	3.8	2.5	2	3.0	102	0.0
2	-6	2.75	0.280	2.56	0.0	9.5	4.2	2.2	2	3.0	102	0.0
3	-4	2.90	0.281	2.54	0.0	1.5	4.4	1.8	2	3.0	102	0.0
4	-4	2.69	0.271	2.39	0.0	7.0	4.6	2.0	2	3.0	102	0.0
5	-5	2.66	0.256	2.51	0.0	7.2	3.4	2.2	2	3.0	102	0.0
6	-6	2.74	0.267	2.16	0.0	0.0	4.4	2.0	2	3.0	102	0.0
7	-5	2.46	0.256	2.15	0.0	2.6	3.4	2.2	2	3.0	102	0.0
8	-3	2.46	0.251	2.24	0.0	3.0	3.4	2.2	2	3.0	102	0.0
9	-6	2.92	0.299	2.72	0.0	9.8	3.2	2.4	2	3.0	102	0.0
10	-6	2.65	0.270	2.38	0.0	9.6	3.0	2.2	2	3.0	102	0.0
11	-5	2.43	0.243	2.25	0.0	1.4	4.0	2.0	2	3.0	102	0.0
12	-7	2.77	0.289	2.76	0.0	9.6	3.2	2.6	2	3.0	102	0.0
13	-6	2.70	0.261	2.56	0.0	5.6	2.8	2.2	2	3.0	102	0.0
14	-4	2.87	0.276	2.48	0.0	8.0	4.6	2.2	2	3.0	102	0.0
15	-4	2.42	0.236	2.30	0.0	4.1	3.4	2.0	2	3.0	102	0.0
16	-6	2.58	0.288	2.70	0.0	13.7	3.2	2.8	2	3.0	102	0.0
17	-5	2.63	0.282	2.54	0.0	1.4	3.8	2.8	2	3.0	102	0.0
18	-7	2.61	0.284	2.56	0.0	2.9	4.0	2.0	2	3.0	102	0.0
19	-7	2.72	0.268	2.40	0.0	6.8	3.6	2.0	2	3.0	102	0.0
20	-4	2.69	0.268	2.60	0.0	4.1	3.6	2.4	2	3.0	102	0.0
21	-4	2.72	0.286	2.50	0.0	5.9	3.0	2.0	2	3.0	102	0.0
22	-5	2.75	0.258	2.39	0.0	2.6	3.4	2.0	2	3.0	102	0.0
23	-4	2.69	0.274	2.58	0.0	2.6	3.6	2.0	2	3.0	102	0.0
24	-7	2.68	0.271	2.48	0.0	3.7	1.6	4.0	2	3.0	102	0.0
25	-4	2.78	0.284	2.42	0.0	8.4	3.7	2.2	2	3.0	102	0.0

SITE NO. 23

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6E-3A	NON-STRESS INDEX	REL. PS SHAW
1	60.0	15700	5.2	94	18	10	8	271	90	6.10	6.30	57	31.65	7.04
2	75.7	13700	11.9	74	18	12	8	226	90	6.20	6.30	57	31.65	7.04
3	36.8	15400	29.8	94	18	7	8	241	90	6.25	6.30	57	31.65	7.04
4	76.8	16000	4.1	70	18	10	8	263	90	6.10	6.30	57	31.65	7.04
5	75.2	17000	3.8	87	18	10	8	278	90	6.10	6.30	57	31.65	7.04
6	62.8	16000	10.2	88	18	8	8	280	90	6.25	6.30	57	31.65	7.04
7	68.2	18000	10.9	83	18	8	8	282	90	6.15	6.30	57	31.65	7.04
8	66.7	14700	11.1	73	18	10	8	224	90	6.05	6.30	57	31.65	7.04
9	53.2	15400	10.6	82	18	5	8	243	90	6.25	6.20	57	31.65	7.04
10	69.0	16700	5.9	64	18	8	8	247	90	6.15	6.30	57	31.65	7.04
11	71.2	17300	9.4	60	18	14	8	235	90	6.10	6.30	57	31.65	7.04
12	74.8	17000	9.6	71	18	8	8	208	90	6.25	6.30	57	31.65	7.04
13	62.8	17000	5.9	80	18	11	8	211	90	6.10	6.30	57	31.65	7.04
14	84.6	15700	4.2	52	18	8	8	194	90	6.15	6.30	57	31.65	7.04
15	70.3	15700	16.7	83	18	10	8	224	90	6.20	6.30	57	31.65	7.04
16	80.7	16700	5.9	73	18	10	8	279	90	6.10	6.30	57	31.65	7.04
17	65.2	14700	6.7	78	18	11	8	308	90	6.10	6.30	57	31.65	7.04
18	74.4	17300	7.5	69	18	9	8	252	90	6.05	6.30	57	31.65	7.04
19	48.7	14700	15.6	72	18	8	8	225	90	6.20	6.30	57	31.65	7.04
20	77.8	18300	5.7	69	18	10	8	174	90	6.05	6.30	57	31.65	7.04
21	70.8	15700	12.5	83	18	9	8	185	90	6.10	6.30	57	31.65	7.04
22	64.6	14700	15.6	82	18	8	8	292	90	6.10	6.30	57	31.65	7.04
23	69.3	15000	8.7	84	18	8	8	226	90	6.30	6.30	57	31.65	7.04
24	73.3	15400	6.4	89	18	8	8	278	90	6.25	6.30	57	31.65	7.04
25	75.6	17600	10.1	80	18	10	8	306	90	6.20	6.30	57	31.65	7.04

SITE NO. 23(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD PCT.	WEEDS 300#/UNIT
1	-4	2.32	0.186	2.26	0.0	4.5	0.0	0.0	7	1.0	90	0.0
2	-5	2.72	0.244	2.28	0.0	12.5	0.0	0.0	7	1.0	90	0.0
3	1	2.33	0.145	2.28	0.0	8.1	0.0	0.0	7	1.0	90	0.0
4	-5	2.44	0.256	2.52	0.0	5.2	0.0	0.0	7	1.0	90	0.0
5	-4	2.56	0.230	2.66	0.0	2.5	0.0	0.0	7	1.0	90	0.0
6	-4	2.53	0.176	2.30	0.0	4.0	0.0	0.0	7	1.0	90	0.0
7	-5	2.19	0.195	2.22	0.0	3.9	0.0	0.0	7	1.0	90	0.0
8	-3	2.41	0.206	2.42	0.0	2.7	0.0	0.0	7	1.0	90	0.0
9	-4	2.49	0.218	2.74	0.0	0.0	0.0	0.0	7	1.0	90	0.0
10	-3	2.48	0.202	2.50	0.0	1.4	0.0	0.0	7	1.0	90	0.0
11	-4	2.54	0.240	2.26	0.0	5.4	0.0	0.0	7	1.0	90	0.0
12	-3	2.35	0.206	2.40	0.0	4.4	0.0	0.0	7	1.0	90	0.0
13	-5	2.68	0.240	2.31	0.0	1.3	0.0	0.0	7	1.0	90	0.0
14	-6	2.58	0.254	2.32	0.0	4.5	0.0	0.0	7	1.0	90	0.0
15	-3	2.35	0.225	2.26	0.0	4.1	0.0	0.0	7	1.0	90	0.0
16	-5	2.31	0.249	2.30	0.0	1.4	0.0	0.0	7	1.0	90	0.0
17	-6	2.48	0.228	2.38	0.0	3.6	0.0	0.0	7	1.0	90	0.0
18	-5	2.53	0.245	2.30	0.0	1.3	0.0	0.0	7	1.0	90	0.0
19	-4	2.61	0.235	2.44	0.0	1.3	0.0	0.0	7	1.0	90	0.0
20	-4	2.50	0.185	2.22	0.0	0.0	0.0	0.0	7	1.0	90	0.0
21	-4	2.60	0.253	2.36	0.0	2.9	0.0	0.0	7	1.0	90	0.0
22	-3	2.66	0.227	2.70	0.0	4.4	0.0	0.0	7	1.0	90	0.0
23	-4	2.51	0.211	2.12	0.0	7.1	0.0	0.0	7	1.0	90	0.0
24	-6	2.49	0.218	2.06	0.0	4.5	0.0	0.0	7	1.0	90	0.0
25	-3	2.50	0.222	2.44	0.0	4.4	0.0	0.0	7	1.0	90	0.0

SITE NO. 26

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR- REN %	SOIL N PP2M	SUB- SOIL N PP2M	SOIL P PP2M	SUB- SOIL P PP2M	SOIL K PP2M	SUB- SOIL K PP2M	SOIL PH	SUB- SOIL PH	STRESS DAYS 6B-2A	NON- STRESS INDEX	REL. PS SHAW
1	100.1	13200	1.3	53	16	19	6	210	78	6.95	7.30	39	47.01	30.09
2	99.4	12400	0.0	52	16	24	6	189	78	6.75	7.30	39	47.01	30.09
3	108.4	12700	0.0	70	16	19	6	199	78	6.90	7.30	39	47.01	30.09
4	103.7	14800	2.4	58	16	30	6	246	78	6.80	7.30	39	47.01	30.09
5	92.5	13800	2.6	62	16	28	6	161	78	7.10	7.30	39	47.01	30.09
6	108.9	13400	0.0	50	16	21	6	159	78	7.10	7.30	39	47.01	30.09
7	100.3	13800	2.6	52	16	18	6	206	78	7.25	7.30	39	47.01	30.09
8	121.1	15500	0.0	60	16	17	6	208	78	7.45	7.30	39	47.01	30.09
9	89.4	13400	5.4	68	16	16	6	203	78	7.15	7.30	39	47.01	30.09
10	107.8	13800	5.0	48	16	17	6	152	78	7.05	7.30	39	47.01	30.09
11	103.2	13100	5.3	54	16	14	6	171	78	7.45	7.30	39	47.01	30.09
12	100.2	13400	0.0	58	16	12	6	189	78	7.15	7.30	39	47.01	30.09
13	97.4	15100	11.4	50	16	22	6	210	78	6.65	7.30	39	47.01	30.09
14	110.7	15500	0.0	56	16	22	6	185	78	7.00	7.30	39	47.01	30.09
15	101.6	16900	2.0	62	16	16	6	209	78	7.00	7.30	39	47.01	30.09
16	94.4	12700	2.8	56	16	18	6	203	78	7.05	7.30	39	47.01	30.09
17	96.4	15500	6.7	66	16	22	6	209	78	6.95	7.30	39	47.01	30.09
18	90.3	14400	4.8	52	16	16	6	217	78	6.95	7.30	39	47.01	30.09
19	93.3	12700	0.0	65	16	17	6	192	78	7.25	7.30	39	47.01	30.09
20	90.8	13100	5.3	59	16	15	6	209	78	7.05	7.30	39	47.01	30.09
21	96.0	13800	12.5	55	16	24	6	213	78	6.70	7.30	39	47.01	30.09
22	100.9	12000	2.9	58	16	19	6	196	78	6.95	7.30	39	47.01	30.09
23	96.4	13400	7.7	57	16	21	6	225	78	7.40	7.30	39	47.01	30.09
24	91.8	12400	5.9	60	16	24	6	181	78	7.15	7.30	39	47.01	30.09
25	93.8	12900	2.7	60	16	17	6	207	78	6.90	7.30	39	47.01	30.09

SITE NO. 26(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM- AGE	PLANT. DATE MAY1=1	PAST CROP- PING	SOIL YIELD PCT.	WEEDS 300#/ UNIT
1	-4	2.76	0.269	2.31	0.0	0.0	0.0	0.0	3	1.7	90	0.0
2	-5	3.01	0.295	2.43	0.0	0.0	0.0	0.0	3	1.7	90	0.0
3	-1	2.97	0.287	2.58	0.0	0.0	0.0	0.0	3	1.7	90	0.0
4	-5	2.79	0.303	2.50	0.0	0.0	0.0	0.0	3	1.7	90	0.0
5	-4	2.88	0.305	2.66	0.0	0.0	0.0	0.0	3	1.7	90	0.0
6	-3	2.88	0.256	1.79	0.0	0.0	0.0	0.0	3	1.7	90	0.0
7	-3	2.60	0.289	2.12	0.0	0.0	0.0	0.0	3	1.7	90	0.0
8	-4	2.65	0.275	2.46	0.0	0.0	0.0	0.0	3	1.7	90	0.0
9	-3	2.92	0.282	2.41	0.0	0.0	0.0	0.0	3	1.7	90	0.0
10	-3	2.75	0.272	2.16	0.0	0.0	0.0	0.0	3	1.7	90	0.0
11	-4	2.84	0.307	2.15	0.0	0.0	0.0	0.0	3	1.7	90	0.0
12	-4	2.82	0.266	2.07	0.0	0.0	0.0	0.0	3	1.7	90	0.0
13	-3	2.94	0.298	2.70	0.0	0.0	0.0	0.0	3	1.7	90	0.0
14	-3	2.83	0.287	2.38	0.0	0.0	0.0	0.0	3	1.7	90	0.0
15	-3	2.68	0.272	2.52	0.0	0.0	0.0	0.0	3	1.7	90	0.0
16	-3	2.97	0.260	2.40	0.0	0.0	0.0	0.0	3	1.7	90	0.0
17	-5	2.80	0.288	2.54	0.0	0.0	0.0	0.0	3	1.7	90	0.0
18	-4	2.93	0.298	2.47	0.0	0.0	0.0	0.0	3	1.7	90	0.0
19	-4	3.21	0.267	2.24	0.0	0.0	0.0	0.0	3	1.7	90	0.0
20	-2	2.89	0.260	2.48	0.0	0.0	0.0	0.0	3	1.7	90	0.0
21	-4	2.88	0.288	2.72	0.0	0.0	0.0	0.0	3	1.7	90	0.0
22	-2	2.84	0.280	2.49	0.0	0.0	0.0	0.0	3	1.7	90	0.0
23	-5	2.93	0.295	2.31	0.0	0.0	0.0	0.0	3	1.7	90	0.0
24	-3	2.90	0.275	2.14	0.0	0.0	0.0	0.0	3	1.7	90	0.0
25	-3	2.98	0.290	2.32	0.0	0.0	0.0	0.0	3	1.7	90	0.0

SITE NO. 27

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS GE-3A	NON-STRESS INDEX	REL. PS SHAW
1	57.4	14700	4.4	59	18	20	12	232	94	5.95	6.45	45	39.47	21.41
2	77.4	14400	6.8	57	18	36	12	215	94	6.05	6.45	45	39.47	21.41
3	73.2	13700	4.8	60	18	22	12	242	94	6.05	6.45	45	39.47	21.41
4	59.8	13100	12.5	50	18	26	12	200	94	5.95	6.45	45	39.47	21.41
5	81.0	15700	6.2	59	18	26	12	232	94	6.05	6.45	45	39.47	21.41
6	74.9	15000	8.7	56	18	30	12	216	94	5.95	6.45	45	39.47	21.41
7	71.8	16300	8.0	60	18	25	12	234	94	6.10	6.45	45	39.47	21.41
8	66.3	16300	10.0	65	18	28	12	214	94	6.10	6.45	45	39.47	21.41
9	89.9	15700	0.0	60	18	23	12	241	94	5.70	6.45	45	39.47	21.41
10	73.5	14400	6.8	66	18	21	12	206	94	6.10	6.45	45	39.47	21.41
11	81.4	13100	5.0	71	18	58	12	232	94	6.00	6.45	45	39.47	21.41
12	78.6	13700	7.1	56	18	26	12	218	94	6.00	6.45	45	39.47	21.41
13	61.1	11800	2.8	49	18	28	12	210	94	5.80	6.45	45	39.47	21.41
14	72.8	15700	12.5	57	18	25	12	241	94	6.00	6.45	45	39.47	21.41
15	77.8	14400	2.3	54	18	28	12	226	94	5.85	6.45	45	39.47	21.41
16	59.2	11800	2.8	64	18	19	12	214	94	5.80	6.45	45	39.47	21.41
17	71.2	16300	2.2	54	18	30	12	226	94	6.00	6.45	45	39.47	21.41
18	74.2	12400	5.3	65	18	22	12	236	94	6.00	6.45	45	39.47	21.41
19	68.9	15000	8.7	65	18	26	12	218	94	6.10	6.45	45	39.47	21.41
20	78.3	14400	6.8	62	18	24	12	242	94	5.95	6.45	45	39.47	21.41
21	70.2	15000	8.7	60	18	24	12	212	94	5.90	6.45	45	39.47	21.41
22	75.1	14700	11.1	71	18	34	12	218	94	5.85	6.45	45	39.47	21.41
23	82.7	14000	2.3	54	18	22	12	198	94	5.85	6.45	45	39.47	21.41
24	56.5	14000	11.6	50	18	18	12	210	94	5.95	6.45	45	39.47	21.41
25	80.0	13600	3.8	64	18	37	12	240	94	5.80	6.45	45	39.47	21.41

SITE NO. 27(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD PCT.	WEEDS 300#/UNIT
1	-4	2.62	0.250	2.42	0.0	31.7	0.0	0.0	10	1.0	98	0.0
2	-6	3.11	0.314	2.21	0.0	20.2	0.0	0.0	10	1.0	98	0.0
3	-4	2.91	0.270	2.40	0.0	27.6	0.0	0.0	10	1.0	98	0.0
4	-5	2.56	0.265	2.47	0.0	14.3	0.0	0.0	10	1.0	98	0.0
5	-3	3.21	0.299	2.50	0.0	29.8	0.0	0.0	10	1.0	98	0.0
6	-6	2.93	0.279	2.28	0.0	33.9	0.0	0.0	10	1.0	98	0.0
7	-4	2.55	0.290	2.17	0.0	23.2	0.0	0.0	10	1.0	98	0.0
8	-6	2.83	0.278	2.48	0.0	25.8	0.0	0.0	10	1.0	98	0.0
9	-4	3.08	0.268	2.50	0.0	20.0	0.0	0.0	10	1.0	98	0.0
10	-5	3.09	0.275	2.42	0.0	24.3	0.0	0.0	10	1.0	98	0.0
11	-6	2.78	0.272	2.32	0.0	29.3	0.0	0.0	10	1.0	98	0.0
12	-3	2.97	0.289	2.32	0.0	29.7	0.0	0.0	10	1.0	98	0.0
13	-7	3.00	0.292	2.33	0.0	15.3	0.0	0.0	10	1.0	98	0.0
14	-5	2.85	0.288	2.44	0.0	18.5	0.0	0.0	10	1.0	98	0.0
15	-7	2.60	0.256	2.44	0.0	15.7	0.0	0.0	10	1.0	98	0.0
16	-4	2.69	0.273	2.39	0.0	19.7	0.0	0.0	10	1.0	98	0.0
17	-6	2.88	0.282	2.27	0.0	20.3	0.0	0.0	10	1.0	98	0.0
18	-5	3.03	0.302	2.38	0.0	19.3	0.0	0.0	10	1.0	98	0.0
19	-6	2.77	0.275	2.32	0.0	21.3	0.0	0.0	10	1.0	98	0.0
20	-3	3.04	0.263	2.30	1.9	38.9	0.0	0.0	10	1.0	98	0.0
21	-6	3.09	0.275	2.60	0.0	20.2	0.0	0.0	10	1.0	98	0.0
22	-5	2.99	0.295	2.36	0.0	34.7	0.0	0.0	10	1.0	98	0.0
23	-7	2.83	0.279	2.50	0.0	20.9	0.0	0.0	10	1.0	98	0.0
24	-7	2.77	0.281	2.17	0.0	35.6	0.0	0.0	10	1.0	98	0.0
25	-7	2.88	0.285	2.44	0.0	28.5	0.0	0.0	10	1.0	98	0.0

SITE NO. 29

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6B-3A	NON-STRESS INDEX	REL. PS SHAW
1	102.8	17000	1.2	69	11	38	16	427	135	5.80	6.25	42	42.94	24.70
2	94.3	16900	4.1	72	11	54	16	465	135	5.70	6.25	42	42.94	24.70
3	101.8	14400	2.4	84	11	58	16	332	135	6.05	6.25	42	42.94	24.70
4	89.2	13100	2.6	91	11	70	16	678	135	5.90	6.25	42	42.94	24.70
5	98.5	16200	8.5	82	11	56	16	281	135	5.95	6.25	42	42.94	24.70
6	100.8	14400	2.4	62	11	49	16	433	135	5.80	6.25	42	42.94	24.70
7	111.2	15800	4.3	75	11	44	16	271	135	6.15	6.25	42	42.94	24.70
8	109.0	16900	6.1	68	11	48	16	405	135	5.70	6.25	42	42.94	24.70
9	88.1	17200	6.0	77	11	56	16	325	135	5.90	6.25	42	42.94	24.70
10	105.8	17900	3.8	90	11	48	16	462	135	5.80	6.25	42	42.94	24.70
11	91.4	15100	2.3	88	11	40	16	249	135	5.90	6.25	42	42.94	24.70
12	87.1	14800	4.7	68	11	42	16	254	135	6.10	6.25	42	42.94	24.70
13	103.8	15500	2.2	77	11	62	16	603	135	5.80	6.25	42	42.94	24.70
14	113.0	15500	4.4	70	11	60	16	425	135	6.00	6.25	42	42.94	24.70
15	82.9	15500	6.7	61	11	56	16	407	135	5.85	6.25	42	42.94	24.70
16	112.2	15800	0.0	63	11	44	16	512	135	6.15	6.25	42	42.94	24.70
17	78.8	11300	0.0	82	11	58	16	331	135	6.00	6.25	42	42.94	24.70
18	106.7	16900	0.0	88	11	60	16	476	135	5.95	6.25	42	42.94	24.70
19	93.7	15100	4.5	74	11	34	16	269	135	6.05	6.25	42	42.94	24.70
20	89.2	18600	5.6	78	11	40	16	363	135	5.90	6.25	42	42.94	24.70
21	96.2	15100	9.1	70	11	27	16	190	135	6.10	6.25	42	42.94	24.70
22	115.6	15500	4.4	73	11	54	16	486	135	5.85	6.25	42	42.94	24.70
23	94.1	17200	4.0	68	11	44	16	376	135	5.75	6.25	42	42.94	24.70
24	[illegible]	[illegible]	[illegible]	[illegible]	11	64	16	485	135	5.80	6.25	42	42.94	24.70
25	96.0	17000	4.8	75	11	38	16	326	135	5.85	6.25	42	42.94	24.70

SITE NO. 29(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD PCT.	WEEDS 300#/ UNIT
1	-4	3.00	0.300	2.67	1.4	7.3	0.0	0.0	3	1.7	107	0.0
2	-2	3.23	0.306	2.68	5.5	6.8	0.0	0.0	3	1.7	107	0.0
3	0	2.99	0.295	2.52	25.4	13.6	0.0	0.0	3	1.7	107	0.0
4	-2	3.01	0.307	2.56	1.4	8.3	0.0	0.0	3	1.7	107	0.0
5	-4	3.24	0.305	2.50	1.5	6.1	0.0	0.0	3	1.7	107	0.0
6	-3	3.35	0.306	2.78	10.3	8.8	0.0	0.0	3	1.7	107	0.0
7	-4	2.83	0.293	2.74	1.3	9.2	0.0	0.0	3	1.7	107	0.0
8	-3	3.02	0.290	3.12	2.6	5.2	0.0	0.0	3	1.7	107	0.0
9	-2	3.08	0.296	3.02	9.3	12.0	0.0	0.0	3	1.7	107	0.0
10	-5	3.30	0.296	2.58	0.0	5.2	0.0	0.0	3	1.7	107	0.0
11	-3	3.06	0.297	2.72	1.3	5.3	0.0	0.0	3	1.7	107	0.0
12	-2	3.03	0.305	2.52	9.4	6.3	0.0	0.0	3	1.7	107	0.0
13	-3	3.28	0.313	2.80	8.1	6.8	0.0	0.0	3	1.7	107	0.0
14	-3	3.17	0.307	2.92	6.3	1.6	0.0	0.0	3	1.7	107	0.0
15	-3	2.81	0.284	2.72	0.0	8.6	0.0	0.0	3	1.7	107	0.0
16	-2	2.95	0.299	2.64	11.7	0.0	0.0	0.0	3	1.7	107	0.0
17	-1	3.19	0.303	2.62	3.0	12.2	0.0	0.0	3	1.7	107	0.0
18	-5	3.45	0.312	2.76	1.3	9.4	0.0	0.0	3	1.7	107	0.0
19	-4	2.91	0.287	2.52	5.5	8.2	0.0	0.0	3	1.7	107	0.0
20	-3	3.23	0.298	2.62	1.3	10.6	0.0	0.0	3	1.7	107	0.0
21	-1	3.20	0.308	2.66	5.8	2.8	0.0	0.0	3	1.7	107	0.0
22	-1	3.03	0.293	2.54	5.9	4.4	0.0	0.0	3	1.7	107	0.0
23	-5	3.10	0.288	2.56	3.9	5.2	0.0	0.0	3	1.7	107	0.0
24	-5	3.26	0.302	2.72	5.3	10.7	0.0	0.0	3	1.7	107	0.0
25	-5	3.17	0.303	2.64	2.0	7.2	0.0	0.0	3	1.7	107	0.0

SITE NO. 31

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6E-3A	NON-STRESS INDEX	REL. PS SHAW
1	113.3	15100	4.6	52	19	26	14	416	239	6.05	6.20	29	54.48	40.03
2	113.3	14500	0.0	73	19	25	14	369	239	5.95	6.20	29	54.48	40.03
3	125.4	17200	2.0	54	19	50	14	335	239	6.05	6.20	29	54.48	40.03
4	104.8	14800	0.0	54	19	56	14	346	239	6.10	6.20	29	54.48	40.03
5	126.8	15100	2.3	52	19	38	14	347	239	6.10	6.20	29	54.48	40.03
6	115.2	16200	4.3	58	19	23	14	379	239	6.00	6.20	29	54.48	40.03
7	96.4	14800	4.7	72	19	26	14	382	239	6.00	6.20	29	54.48	40.03
8	106.7	14400	2.4	49	19	24	14	367	239	6.10	6.20	29	54.48	40.03
9	119.0	14100	0.0	60	19	34	14	274	239	6.20	6.20	29	54.48	40.03
10	108.9	13800	0.0	53	19	29	14	427	239	6.00	6.20	29	54.48	40.03
11	124.3	16500	2.1	52	19	22	14	288	239	6.10	6.20	29	54.48	40.03
12	110.3	15800	2.2	56	19	17	14	219	239	6.10	6.20	29	54.48	40.03
13	119.2	14100	0.0	56	19	27	14	439	239	6.00	6.20	29	54.48	40.03
14	113.0	13800	0.0	72	19	18	14	407	239	6.15	6.20	29	54.48	40.03
15	115.6	13800	2.5	58	19	26	14	344	239	6.05	6.20	29	54.48	40.03
16	123.8	17200	2.0	59	19	16	14	314	239	6.00	6.20	29	54.48	40.03
17	129.8	17200	0.0	50	19	31	14	327	239	6.10	6.20	29	54.48	40.03
18	129.0	16200	0.0	48	19	65	14	307	239	6.00	6.20	29	54.48	40.03
19	125.9	16500	0.0	52	19	37	14	310	239	6.10	6.20	29	54.48	40.03
20	116.8	15500	2.2	55	19	27	14	442	239	6.20	6.20	29	54.48	40.03
21	126.2	15500	0.0	62	19	28	14	287	239	6.00	6.20	29	54.48	40.03
22	123.8	16500	2.1	50	19	32	14	279	239	6.10	6.20	29	54.48	40.03
23	98.9	13400	7.7	54	19	30	14	218	239	6.05	6.20	29	54.48	40.03
24	104.6	15800	4.3	60	19	24	14	305	239	6.00	6.20	29	54.48	40.03
25	109.8	15200	1.0	50	19	24	14	414	239	6.00	6.20	29	54.48	40.03

SITE NO. 31(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD POT.	WEEDS 300#/ UNIT
1	-8	2.74	0.273	2.42	0.0	27.8	0.0	0.0	5	1.7	100	1.0
2	-8	3.08	0.310	2.24	0.0	28.1	0.0	0.0	5	1.7	100	1.0
3	-6	3.26	0.273	2.40	0.0	21.7	0.0	0.0	5	1.7	100	1.0
4	-7	2.49	0.283	2.48	0.0	15.1	0.0	0.0	5	1.7	100	1.0
5	-7	3.16	0.355	2.28	0.0	24.6	0.0	0.0	5	1.7	100	1.0
6	-6	3.41	0.270	2.32	0.0	21.3	0.0	0.0	5	1.7	100	1.0
7	-7	2.65	0.305	2.34	0.0	25.4	0.0	0.0	5	1.7	100	1.0
8	-7	2.59	0.268	2.40	0.0	24.3	0.0	0.0	5	1.7	100	1.0
9	-7	2.78	0.279	2.08	0.0	26.1	0.0	0.0	5	1.7	100	1.0
10	-7	3.09	0.300	2.40	0.0	18.0	0.0	0.0	5	1.7	100	1.0
11	-8	2.54	0.282	2.56	0.0	6.9	0.0	0.0	5	1.7	100	1.0
12	-6	2.56	0.256	2.38	0.0	4.5	0.0	0.0	5	1.7	100	1.0
13	-7	3.08	0.291	2.38	0.0	32.2	0.0	0.0	5	1.7	100	1.0
14	-5	3.07	0.285	2.62	0.0	18.9	0.0	0.0	5	1.7	100	1.0
15	-8	2.80	0.300	2.38	0.0	19.1	0.0	0.0	5	1.7	100	1.0
16	-6	2.79	0.289	2.28	1.6	12.9	0.0	0.0	5	1.7	100	1.0
17	-7	2.89	0.291	2.34	0.0	24.2	0.0	0.0	5	1.7	100	1.0
18	-8	3.02	0.306	2.24	1.6	11.1	0.0	0.0	5	1.7	100	1.0
19	-6	3.13	0.278	2.34	0.0	26.9	0.0	0.0	5	1.7	100	1.0
20	-5	2.98	0.277	2.54	0.0	30.4	0.0	0.0	5	1.7	100	1.0
21	-7	2.88	0.296	2.32	0.0	23.0	0.0	0.0	5	1.7	100	1.0
22	-8	2.70	0.292	2.40	0.0	35.2	0.0	0.0	5	1.7	100	1.0
23	-8	3.02	0.279	2.44	0.0	25.5	0.0	0.0	5	1.7	100	1.0
24	-7	2.93	0.274	2.48	0.0	36.4	0.0	0.0	5	1.7	100	1.0
25	-8	2.89	0.280	2.54	0.0	14.3	0.0	0.0	5	1.7	100	1.0

SITE NO. 32

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6B-3A	NON-STRESS INDEX	REL. PS SHAW
1	110.3	16400	1.0	54	17	25	10	166	107	6.65	6.80	27	55.44	42.95
2	108.8	15700	2.1	46	17	21	10	205	107	6.70	6.80	27	55.44	42.95
3	121.4	16700	0.0	74	17	25	10	227	107	7.00	6.80	27	55.44	42.95
4	102.1	16000	4.1	42	17	22	10	216	107	6.75	6.80	27	55.44	42.95
5	126.8	17600	1.9	36	17	29	10	220	107	6.85	6.80	27	55.44	42.95
6	118.2	17300	0.0	63	17	25	10	226	107	7.00	6.80	27	55.44	42.95
7	100.7	14000	0.0	57	17	21	10	196	107	6.80	6.80	27	55.44	42.95
8	115.9	16700	3.9	56	17	18	10	197	107	7.10	6.80	27	55.44	42.95
9	112.1	16300	2.0	55	17	20	10	215	107	6.60	6.80	27	55.44	42.95
10	95.8	14400	2.3	64	17	24	10	221	107	7.00	6.80	27	55.44	42.95
11	111.0	15700	4.2	54	17	20	10	222	107	6.95	6.80	27	55.44	42.95
12	105.3	15700	2.1	79	17	24	10	268	107	6.85	6.80	27	55.44	42.95
13	132.2	16300	0.0	70	17	24	10	257	107	6.65	6.80	27	55.44	42.95
14	123.8	15700	0.0	51	17	30	10	221	107	7.00	6.80	27	55.44	42.95
15	111.2	16700	5.9	56	17	26	10	220	107	6.80	6.80	27	55.44	42.95
16	107.2	15400	0.0	57	17	20	10	184	107	6.65	6.80	27	55.44	42.95
17	115.2	16700	5.9	38	17	20	10	238	107	6.90	6.80	27	55.44	42.95
18	113.6	15400	2.1	82	17	20	10	117	107	6.90	6.80	27	55.44	42.95
19	123.1	17000	0.0	53	17	28	10	242	107	6.80	6.80	27	55.44	42.95
20	116.3	15000	0.0	70	17	23	10	175	107	6.85	6.80	27	55.44	42.95
21	125.7	18300	1.8	66	17	26	10	231	107	6.95	6.80	27	55.44	42.95
22	118.8	16700	0.0	49	17	24	10	218	107	6.85	6.80	27	55.44	42.95
23	118.2	17000	0.0	53	17	22	10	208	107	6.80	6.80	27	55.44	42.95
24	124.7	16700	0.0	47	17	21	10	239	107	6.65	6.80	27	55.44	42.95
25	115.5	15600	1.0	55	17	26	10	229	107	7.05	6.80	27	55.44	42.95

SITE NO. 32(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD POT.	WEEDS 300#/ UNIT
1	-4	2.78	0.267	2.06	0.0	21.6	0.0	0.0	11	1.7	98	0.0
2	-4	3.12	0.300	2.12	1.6	21.0	0.0	0.0	11	1.7	98	0.0
3	-2	3.18	0.285	2.37	0.0	23.2	0.0	0.0	11	1.7	98	0.0
4	-3	2.44	0.261	2.38	0.0	17.1	0.0	0.0	11	1.7	98	0.0
5	-2	2.99	0.285	2.31	0.0	18.0	0.0	0.0	11	1.7	98	0.0
6	-1	3.06	0.277	2.10	0.0	30.4	0.0	0.0	11	1.7	98	0.0
7	-5	2.48	0.267	2.10	1.6	31.1	0.0	0.0	11	1.7	98	0.0
8	-3	2.78	0.304	2.28	0.0	25.8	0.0	0.0	11	1.7	98	0.0
9	-2	3.03	0.277	2.40	0.0	21.5	0.0	0.0	11	1.7	98	0.0
10	-2	2.99	0.283	2.20	1.4	31.8	0.0	0.0	11	1.7	98	0.0
11	-4	2.91	0.314	2.20	0.0	17.2	0.0	0.0	11	1.7	98	0.0
12	-4	2.98	0.282	2.40	0.0	25.0	0.0	0.0	11	1.7	98	0.0
13	-1	3.18	0.296	2.60	0.0	27.0	0.0	0.0	11	1.7	98	0.0
14	-3	2.82	0.268	2.12	1.5	29.4	0.0	0.0	11	1.7	98	0.0
15	-3	2.81	0.293	2.30	0.0	15.3	0.0	0.0	11	1.7	98	0.0
16	-3	2.81	0.340	2.28	0.0	24.6	0.0	0.0	11	1.7	98	0.0
17	-5	3.10	0.298	2.22	0.0	28.1	0.0	0.0	11	1.7	98	0.0
18	-5	3.09	0.275	2.12	0.0	11.7	0.0	0.0	11	1.7	98	0.0
19	-2	3.21	0.278	2.41	0.0	22.5	0.0	0.0	11	1.7	98	0.0
20	-2	3.13	0.260	2.32	0.0	16.1	0.0	0.0	11	1.7	98	0.0
21	-3	3.06	0.280	2.44	0.0	27.9	0.0	0.0	11	1.7	98	0.0
22	-3	2.95	0.276	2.18	0.0	37.1	0.0	0.0	11	1.7	98	0.0
23	-6	3.02	0.284	2.06	0.0	20.8	0.0	0.0	11	1.7	98	0.0
24	-6	2.92	0.294	2.26	0.0	23.9	0.0	0.0	11	1.7	98	0.0
25	-4	3.04	0.282	2.24	0.0	18.7	0.0	0.0	11	1.7	98	0.0

SITE NO. 33

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6B-3A	NON-STRESS INDEX	REL. PS SHAW
1	80.4	20800	3.2	54	20	16	10	188	78	6.90	6.40	36	49.77	34.08
2	102.5	17500	1.9	60	20	16	10	177	78	7.05	6.40	36	49.77	34.08
3	80.9	22000	4.7	44	20	18	10	188	78	7.05	6.40	36	49.77	34.08
4	82.5	18600	1.9	50	20	32	10	205	78	7.00	6.40	36	49.77	34.08
5	90.3	18200	3.8	44	20	18	10	181	78	6.70	6.40	36	49.77	34.08
6	69.7	22400	1.5	56	20	22	10	188	78	6.95	6.40	36	49.77	34.08
7	85.3	23400	5.9	47	20	16	10	214	78	6.85	6.40	36	49.77	34.08
8	66.0	16900	4.1	61	20	12	10	149	78	6.95	6.40	36	49.77	34.08
9	85.5	23400	5.9	54	20	14	10	191	78	6.70	6.40	36	49.77	34.08
10	92.9	22400	1.5	53	20	15	10	199	78	6.75	6.40	36	49.77	34.08
11	93.8	22000	3.1	54	20	15	10	164	78	6.75	6.40	36	49.77	34.08
12	74.8	21700	3.2	45	20	15	10	173	78	6.60	6.40	36	49.77	34.08
13	87.1	22700	3.0	51	20	16	10	209	78	7.10	6.40	36	49.77	34.08
14	93.8	17900	3.8	73	20	16	10	187	78	7.00	6.40	36	49.77	34.08
15	87.4	22400	1.5	53	20	17	10	196	78	6.85	6.40	36	49.77	34.08
16	85.5	22700	6.1	44	20	14	10	187	78	6.60	6.40	36	49.77	34.08
17	79.8	22400	3.1	61	20	18	10	381	78	6.80	6.40	36	49.77	34.08
18	75.4	24000	2.9	36	20	16	10	193	78	6.85	6.40	36	49.77	34.08
19	83.7	16500	2.1	43	20	16	10	148	78	6.70	6.40	36	49.77	34.08
20	94.1	22700	1.5	56	20	25	10	187	78	6.60	6.40	36	49.77	34.08
21	81.9	18900	1.8	68	20	16	10	198	78	6.95	6.40	36	49.77	34.08
22	84.6	16200	2.1	58	20	14	10	194	78	6.85	6.40	36	49.77	34.08
23	89.1	22000	1.6	62	20	42	10	221	78	6.95	6.40	36	49.77	34.08
24	84.4	22400	3.1	46	20	13	10	163	78	6.80	6.40	36	49.77	34.08
25	79.2	22600	6.1	56	20	17	10	184	78	6.70	6.40	36	49.77	34.08

SITE NO. 23(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD POT.	WEEDS 300#/UNIT
1	-2	2.76	0.276	2.20	0.0	12.4	0.0	0.0	10	1.7	98	0.0
2	-5	3.01	0.315	1.86	2.6	24.3	0.0	0.0	10	1.7	98	0.0
3	0	3.01	0.273	2.32	1.0	23.5	0.0	0.0	10	1.7	98	0.0
4	-2	2.53	0.277	2.42	0.0	21.2	0.0	0.0	10	1.7	98	0.0
5	-3	2.98	0.299	2.60	0.0	25.6	0.0	0.0	10	1.7	98	0.0
6	0	3.19	0.270	2.24	0.0	31.9	0.0	0.0	10	1.7	98	0.0
7	-4	2.53	0.280	2.14	1.8	16.8	0.0	0.0	10	1.7	98	0.0
8	-2	2.43	0.255	2.00	0.0	11.9	0.0	0.0	10	1.7	98	0.0
9	-2	2.87	0.271	2.18	0.0	15.6	0.0	0.0	10	1.7	98	0.0
10	-1	2.89	0.265	2.12	0.0	25.0	0.0	0.0	10	1.7	98	0.0
11	-2	2.46	0.255	2.09	2.5	16.6	0.0	0.0	10	1.7	98	0.0
12	-1	2.72	0.261	2.30	2.1	18.9	0.0	0.0	10	1.7	98	0.0
13	-2	3.03	0.279	2.41	0.0	24.5	0.0	0.0	10	1.7	98	0.0
14	-2	3.14	0.298	2.22	1.3	38.7	0.0	0.0	10	1.7	98	0.0
15	-2	2.46	0.282	2.42	0.0	17.5	0.0	0.0	10	1.7	98	0.0
16	-2	2.27	0.241	2.34	0.0	11.2	0.0	0.0	10	1.7	98	0.0
17	-3	2.90	0.291	2.34	1.0	26.0	0.0	0.0	10	1.7	98	0.0
18	-2	2.74	0.289	2.42	1.9	25.2	0.0	0.0	10	1.7	98	0.0
19	-3	2.99	0.253	2.12	2.9	28.6	0.0	0.0	10	1.7	98	0.0
20	-5	2.92	0.284	2.14	0.0	25.0	0.0	0.0	10	1.7	98	0.0
21	-3	2.80	0.278	2.30	0.0	17.6	0.0	0.0	10	1.7	98	0.0
22	-2	2.93	0.292	2.09	0.0	5.9	0.0	0.0	10	1.7	98	0.0
23	-6	3.00	0.298	2.02	1.0	26.0	0.0	0.0	10	1.7	98	0.0
24	-3	2.93	0.276	1.94	3.3	14.9	0.0	0.0	10	1.7	98	0.0
25	-2	2.90	0.272	2.28	0.0	25.1	0.0	0.0	10	1.7	98	0.0

SITE NO. 36

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6B-3A	NON-STRESS INDEX	REL. PS SHAW
1	52.2	14800	3.2	60	28	9	5	229	117	6.85	7.05	41	41.76	21.11
2	54.3	13100	5.0	79	28	7	5	191	117	7.00	7.05	41	41.76	21.11
3	51.9	11400	5.7	51	28	7	5	196	117	6.90	7.05	41	41.76	21.11
4	56.6	14000	7.0	61	28	7	5	233	117	6.85	7.05	41	41.76	21.11
5	59.3	14700	4.4	64	28	9	5	370	117	6.80	7.05	41	41.76	21.11
6	58.2	11800	0.0	49	28	8	5	198	117	6.95	7.05	41	41.76	21.11
7	50.4	13700	7.1	69	28	8	5	244	117	6.90	7.05	41	41.76	21.11
8	42.2	12700	7.7	52	28	8	5	242	117	6.85	7.05	41	41.76	21.11
9	49.8	13100	5.0	65	28	8	5	232	117	6.95	7.05	41	41.76	21.11
10	62.1	12400	2.6	55	28	8	5	125	117	6.90	7.05	41	41.76	21.11
11	35.0	13400	2.2	62	28	8	5	248	117	6.90	7.05	41	41.76	21.11
12	61.0	12700	2.6	50	28	8	5	205	117	7.00	7.05	41	41.76	21.11
13	51.9	14700	6.7	44	28	7	5	205	117	7.00	7.05	41	41.76	21.11
14	60.0	14700	4.4	52	28	8	5	221	117	6.90	7.05	41	41.76	21.11
15	58.4	14400	2.3	59	28	10	5	202	117	7.00	7.05	41	41.76	21.11
16	58.3	15400	2.1	53	28	8	5	202	117	6.90	7.05	41	41.76	21.11
17	47.2	12400	5.3	59	28	9	5	232	117	6.85	7.05	41	41.76	21.11
18	46.7	13100	10.0	62	28	9	5	245	117	6.75	7.05	41	41.76	21.11
19	53.2	13700	2.4	52	28	8	5	220	117	6.85	7.05	41	41.76	21.11
20	40.8	12700	2.6	75	28	9	5	258	117	6.80	7.05	41	41.76	21.11
21	59.8	12700	2.5	60	28	8	5	158	117	7.00	7.05	41	41.76	21.11
22	56.7	13400	2.4	62	28	9	5	231	117	6.80	7.05	41	41.76	21.11
23	52.2	13100	2.5	53	28	8	5	175	117	7.00	7.05	41	41.76	21.11
24	61.8	14400	4.0	56	28	8	5	189	117	6.80	7.05	41	41.76	21.11
25	52.1	13400	6.0	58	28	8	5	217	117	6.90	7.05	41	41.76	21.11

SITE NO. 36(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD FCT.	WEEDS 300#/ UNIT
1	-2	2.98	0.239	2.30	0.0	10.0	0.0	0.0	3	1.5	93	0.0
2	-5	3.29	0.298	2.22	0.0	10.0	0.0	0.0	3	1.5	93	0.0
3	1	3.45	0.252	2.76	0.0	10.0	0.0	0.0	3	1.5	93	0.0
4	-3	2.79	0.275	2.56	0.0	10.0	0.0	0.0	3	1.5	93	0.0
5	-2	3.19	0.290	2.60	0.0	10.0	0.0	0.0	3	1.5	93	0.0
6	-3	3.30	0.255	2.47	0.0	10.0	0.0	0.0	3	1.5	93	0.0
7	-4	2.88	0.296	2.54	0.0	10.0	0.0	0.0	3	1.5	93	0.0
8	2	2.92	0.226	2.32	0.0	10.0	0.0	0.0	3	1.5	93	0.0
9	-4	3.11	0.278	2.59	0.0	10.0	0.0	0.0	3	1.5	93	0.0
10	-2	3.27	0.282	2.24	0.0	10.0	0.0	0.0	3	1.5	93	0.0
11	-4	3.06	0.291	2.48	0.0	10.0	0.0	0.0	3	1.5	93	0.0
12	-4	3.20	0.274	2.11	0.0	10.0	0.0	0.0	3	1.5	93	0.0
13	-2	3.07	0.272	2.58	0.0	10.0	0.0	0.0	3	1.5	93	0.0
14	-3	3.24	0.292	2.42	0.0	10.0	0.0	0.0	3	1.5	93	0.0
15	-3	3.02	0.275	2.36	0.0	10.0	0.0	0.0	3	1.5	93	0.0
16	-4	2.99	0.282	2.46	0.0	10.0	0.0	0.0	3	1.5	93	0.0
17	-4	2.98	0.306	2.48	0.0	10.0	0.0	0.0	3	1.5	93	0.0
18	-3	3.24	0.310	2.46	0.0	10.0	0.0	0.0	3	1.5	93	0.0
19	-1	3.06	0.255	2.42	0.0	10.0	0.0	0.0	3	1.5	93	0.0
20	-2	3.23	0.264	2.44	0.0	10.0	0.0	0.0	3	1.5	93	0.0
21	-3	3.07	0.282	2.42	0.0	10.0	0.0	0.0	3	1.5	93	0.0
22	-4	3.39	0.298	2.36	0.0	10.0	0.0	0.0	3	1.5	93	0.0
23	-5	3.43	0.302	2.09	0.0	10.0	0.0	0.0	3	1.5	93	0.0
24	-4	3.26	0.288	2.36	0.0	10.0	0.0	0.0	3	1.5	93	0.0
25	4	3.16	0.282	2.40	0.0	10.0	0.0	0.0	3	1.5	93	0.0

SITE NO. 38

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6E-3A	NON-STRESS INDEX	REL. PS SPAW
1	87.1	17000	2.8	54	23	22	10	245	89	6.45	6.55	32	52.12	38.84
2	112.0	17600	0.0	45	23	36	10	255	89	6.30	6.55	32	52.12	38.84
3	89.5	14400	2.3	55	23	20	10	221	89	6.10	6.55	32	52.12	38.84
4	85.0	17000	2.8	49	23	25	10	201	89	6.55	6.55	32	52.12	38.84
5	92.8	18000	1.8	57	23	25	10	230	89	6.05	6.55	32	52.12	38.84
6	85.6	16300	0.0	50	23	22	10	220	89	6.40	6.55	32	52.12	38.84
7	85.3	14700	8.9	53	23	20	10	189	89	6.30	6.55	32	52.12	38.84
8	64.3	14700	6.7	49	23	17	10	213	89	6.25	6.55	32	52.12	38.84
9	105.5	19600	13.3	66	23	32	10	252	89	6.25	6.55	32	52.12	38.84
10	116.5	15700	0.0	49	23	20	10	217	89	6.75	6.55	32	52.12	38.84
11	99.0	16700	7.8	59	23	28	10	207	89	6.50	6.55	32	52.12	38.84
12	91.7	14700	0.0	55	23	29	10	289	89	6.20	6.55	32	52.12	38.84
13	97.8	17000	1.3	50	23	27	10	194	89	6.40	6.55	32	52.12	38.84
14	115.8	15400	2.1	67	23	34	10	224	89	6.40	6.55	32	52.12	38.84
15	89.4	15400	6.4	56	23	26	10	244	89	6.40	6.55	32	52.12	38.84
16	82.9	18000	9.1	63	23	27	10	250	89	6.25	6.55	32	52.12	38.84
17	108.9	17000	1.9	62	23	31	10	198	89	6.00	6.55	32	52.12	38.84
18	96.6	18900	5.2	67	23	18	10	281	89	6.40	6.55	32	52.12	38.84
19	103.2	14400	0.0	62	23	28	10	236	89	6.30	6.55	32	52.12	38.84
20	105.2	16700	5.9	42	23	24	10	172	89	6.50	6.55	32	52.12	38.84
21	99.7	17300	9.4	53	23	29	10	222	89	6.45	6.55	32	52.12	38.84
22	77.9	17300	5.7	52	23	20	10	228	89	6.25	6.55	32	52.12	38.84
23	92.6	14700	4.4	55	23	20	10	285	89	6.15	6.55	32	52.12	38.84
24	120.8	17600	0.0	49	23	28	10	164	89	6.60	6.55	32	52.12	38.84
25	101.2	13800	2.4	60	23	21	10	172	89	6.75	6.55	32	52.12	38.84

SITE NO. 38(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD POT.	WEEDS 300#/UNIT
1	4	2.54	0.282	2.35	19.8	2.4	3.9	1.9	4	4.7	93	0.0
2	-7	3.12	0.303	2.60	21.1	3.9	4.0	2.4	4	4.7	93	0.0
3	-5	3.32	0.280	2.54	25.3	4.0	3.6	2.0	4	4.7	93	0.0
4	-5	2.25	0.273	2.72	16.9	4.8	3.6	2.0	4	4.7	93	0.0
5	-6	3.07	0.296	2.62	8.8	4.4	3.8	2.0	4	4.7	93	0.0
6	-5	3.06	0.289	2.60	27.0	5.5	3.8	2.0	4	4.7	93	0.0
7	-5	2.68	0.267	2.30	22.5	2.8	3.8	2.2	4	4.7	93	0.0
8	-2	2.65	0.302	2.44	18.2	1.3	3.6	2.0	4	4.7	93	0.0
9	-5	3.04	0.285	2.58	8.3	3.6	3.2	2.0	4	4.7	93	0.0
10	-6	3.08	0.297	2.20	7.4	0.0	3.6	1.8	4	4.7	93	0.0
11	-6	2.75	0.301	2.62	9.3	5.4	3.6	2.0	4	4.7	93	0.0
12	-4	2.85	0.304	2.48	25.0	0.0	4.2	2.2	4	4.7	93	0.0
13	-5	2.92	0.280	2.30	41.6	0.0	3.2	2.2	4	4.7	93	0.0
14	-6	3.10	0.276	2.52	9.5	5.5	3.8	2.0	4	4.7	93	0.0
15	-5	2.77	0.270	2.54	6.8	2.8	3.2	1.6	4	4.7	93	0.0
16	-3	2.56	0.272	2.48	11.4	2.9	3.0	2.0	4	4.7	93	0.0
17	-6	2.94	0.290	2.44	3.9	5.2	3.2	2.0	4	4.7	93	0.0
18	-5	3.06	0.290	2.50	10.7	2.4	4.2	2.0	4	4.7	93	0.0
19	-5	3.03	0.281	2.61	11.7	6.5	4.2	2.2	4	4.7	93	0.0
20	-6	2.84	0.286	2.48	6.6	2.6	3.6	2.0	4	4.7	93	0.0
21	-5	2.94	0.280	2.56	14.8	1.2	4.0	2.2	4	4.7	93	0.0
22	-5	3.01	0.299	2.30	3.8	1.2	3.2	2.0	4	4.7	93	0.0
23	-5	2.93	0.298	2.40	4.0	4.0	4.6	2.0	4	4.7	93	0.0
24	-6	2.99	0.285	2.08	15.1	1.2	3.2	2.2	4	4.7	93	0.0
25	-6	3.09	0.290	2.19	11.2	6.3	3.8	2.2	4	4.7	93	0.0

SITE NO. 39

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 6B-2A	NON-STRESS INDEX	REL. PS SHAW
1	90.2	21100	16.0	50	25	32	12	232	212	5.95	6.70	41	40.04	24.34
2	93.3	12700	2.7	42	25	20	12	277	212	6.10	6.70	41	40.04	24.34
3	93.5	18200	11.3	47	25	19	12	228	212	5.80	6.70	41	40.04	24.34
4	100.6	25500	25.7	56	25	35	12	293	212	5.90	6.70	41	40.04	24.34
5	104.5	20000	17.2	56	25	34	12	195	212	6.05	6.70	41	40.04	24.34
6	103.5	16200	6.4	46	25	20	12	184	212	6.00	6.70	41	40.04	24.34
7	102.8	17500	17.6	56	25	18	12	255	212	5.90	6.70	41	40.04	24.34
8	41.7	17200	32.0	51	25	20	12	236	212	6.05	6.70	41	40.04	24.34
9	104.4	15100	6.8	60	25	19	12	213	212	5.90	6.70	41	40.04	24.34
10	80.1	28200	39.0	58	25	28	12	242	212	5.95	6.70	41	40.04	24.34
11	67.7	2820	47.6	56	25	24	12	270	212	5.90	6.70	41	40.04	24.34
12	119.4	18900	3.6	52	25	18	12	218	212	5.90	6.70	41	40.04	24.34
13	93.9	13400	12.8	44	25	20	12	202	212	5.80	6.70	41	40.04	24.34
14	104.2	17900	15.4	38	25	22	12	207	212	6.00	6.70	41	40.04	24.34
15	98.4	14400	9.5	46	25	20	12	277	212	6.05	6.70	41	40.04	24.34
16	114.5	17200	12.0	44	25	21	12	209	212	5.95	6.70	41	40.04	24.34
17	121.8	17200	2.0	79	25	41	12	227	212	5.85	6.70	41	40.04	24.34
18	114.5	17200	8.0	45	25	22	12	224	212	5.90	6.70	41	40.04	24.34
19	59.5	27500	43.8	67	25	20	12	267	212	6.00	6.70	41	40.04	24.34
20	75.7	29900	35.6	41	25	15	12	265	212	6.00	6.70	41	40.04	24.34
21	74.0	28200	36.6	44	25	22	12	260	212	5.85	6.70	41	40.04	24.34
22	87.5	28200	29.3	54	25	17	12	261	212	6.00	6.70	41	40.04	24.34
23	116.2	16900	10.2	54	25	29	12	261	212	5.90	6.70	41	40.04	24.34
24	107.1	17200	18.0	68	25	23	12	258	212	5.95	6.70	41	40.04	24.34
25	94.0	20800	22.7	49	25	22	12	212	212	6.00	6.70	41	40.04	24.34

SITE NO. 39(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD POT.	WEEDS 300#/UNIT
1	-5	2.56	0.232	2.07	0.0	6.8	3.3	2.0	1	2.7	107	1.0
2	-4	2.97	0.287	2.34	0.0	12.5	3.6	2.0	1	2.7	107	1.0
3	-5	2.85	0.249	2.28	0.0	65.0	4.0	2.0	1	2.7	107	1.0
4	-7	2.56	0.265	2.22	0.0	8.1	3.6	1.8	1	2.7	107	1.0
5	-6	3.00	0.285	2.44	0.0	13.8	3.8	2.0	1	2.7	107	1.0
6	-5	2.98	0.272	2.14	0.0	10.0	3.6	2.0	1	2.7	107	1.0
7	-4	2.49	0.270	2.18	0.0	3.9	3.8	2.0	1	2.7	107	1.0
8	-2	1.86	0.197	1.88	0.0	1.3	3.2	2.2	1	2.7	107	1.0
9	-3	2.90	0.294	2.44	0.0	1.5	4.6	0.9	1	2.7	107	1.0
10	-6	2.73	0.249	2.50	0.0	13.9	3.2	1.8	1	2.7	107	1.0
11	-5	2.73	0.278	2.40	0.0	11.4	2.6	1.6	1	2.7	107	1.0
12	-5	2.69	0.255	2.05	2.4	20.8	3.0	1.8	1	2.7	107	1.0
13	-4	3.13	0.270	2.12	0.0	12.0	3.4	2.0	1	2.7	107	1.0
14	-5	2.65	0.249	2.08	2.6	21.8	3.6	1.8	1	2.7	107	1.0
15	-4	2.64	0.248	2.18	0.0	12.7	3.8	2.2	1	2.7	107	1.0
16	-4	2.55	0.257	2.34	0.0	5.3	3.4	2.0	1	2.7	107	1.0
17	-5	2.84	0.268	2.24	1.3	9.4	3.6	1.8	1	2.7	107	1.0
18	-5	2.73	0.301	2.26	0.0	12.0	3.2	1.8	1	2.7	107	1.0
19	-4	2.63	0.237	2.28	0.0	15.9	3.2	2.2	1	2.7	107	1.0
20	-6	2.79	0.241	2.36	0.8	6.2	3.2	2.0	1	2.7	107	1.0
21	-6	2.75	0.260	2.52	0.0	12.2	3.0	1.8	1	2.7	107	1.0
22	-7	2.65	0.238	2.52	0.0	8.1	3.6	2.0	1	2.7	107	1.0
23	-5	2.89	0.275	2.06	0.0	6.8	3.8	2.0	1	2.7	107	1.0
24	-4	2.94	0.273	2.44	0.0	20.0	3.2	2.0	1	2.7	107	1.0
25	-5	2.86	0.270	2.40	0.0	9.7	3.8	1.8	1	2.7	107	1.0

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SITE NO. 40

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	SOIL N PP2M	SUB-SOIL N PP2M	SOIL P PP2M	SUB-SOIL P PP2M	SOIL K PP2M	SUB-SOIL K PP2M	SOIL PH	SUB-SOIL PH	STRESS DAYS 68-3A	NON-STRESS INDEX	REL. PS SHAW
1	75.4	19400	18.0	60	9	44	12	270	92	6.45	6.85	21	56.91	47.31
2	107.0	16200	2.1	58	9	29	12	302	92	6.35	6.85	21	56.91	47.31
3	98.2	20300	5.1	50	9	34	12	253	92	6.35	6.85	21	56.91	47.31
4	79.3	17900	7.7	74	9	37	12	341	92	6.10	6.85	21	56.91	47.31
5	77.8	18900	10.9	58	9	28	12	220	92	6.55	6.85	21	56.91	47.31
6	102.9	19300	3.6	56	9	31	12	234	92	6.45	6.85	21	56.91	47.31
7	61.1	18900	23.6	58	9	28	12	268	92	6.60	6.85	21	56.91	47.31
8	80.8	18900	7.3	42	9	41	12	193	92	6.55	6.85	21	56.91	47.31
9	97.9	19300	1.8	63	9	37	12	279	92	6.40	6.85	21	56.91	47.31
10	103.9	18200	5.7	56	9	38	12	353	92	6.35	6.85	21	56.91	47.31
11	101.2	18900	5.5	57	9	47	12	370	92	6.20	6.85	21	56.91	47.31
12	82.5	19300	3.6	54	9	42	12	215	92	6.70	6.85	21	56.91	47.31
13	100.9	19600	5.3	50	9	26	12	184	92	7.05	6.85	21	56.91	47.31
14	120.8	18600	3.7	64	9	38	12	310	92	6.30	6.85	21	56.91	47.31
15	53.3	18600	20.4	48	9	20	12	210	92	6.70	6.85	21	56.91	47.31
16	79.4	17500	11.8	53	9	49	12	322	92	6.25	6.85	21	56.91	47.31
17	102.4	18600	3.7	64	9	29	12	245	92	6.45	6.85	21	56.91	47.31
18	73.1	19300	12.5	47	9	37	12	183	92	6.90	6.85	21	56.91	47.31
19	88.2	19300	7.1	62	9	32	12	308	92	6.35	6.85	21	56.91	47.31
20	73.8	16900	8.2	53	9	25	12	168	92	7.05	6.85	21	56.91	47.31
21	111.2	20000	1.7	48	9	32	12	213	92	6.50	6.85	21	56.91	47.31
22	118.5	19300	5.4	55	9	36	12	248	92	6.50	6.85	21	56.91	47.31
23	92.8	17500	2.0	52	9	38	12	190	92	6.80	6.85	21	56.91	47.31
24	74.1	19300	8.9	56	9	33	12	289	92	6.40	6.85	21	56.91	47.31
25	110.0	20000	7.7	56	9	33	12	238	92	6.70	6.85	21	56.91	47.31

SITE NO. 40(CONT.)

TRT NO.	SILK. DATE AUG1=1	LEAF %N	LEAF %P	LEAF %K	TOTAL ROOT LODG%	TOTAL STALK LODG%	ROOT SIZE	ROOT DAM-AGE	PLANT. DATE MAY1=1	PAST CROP-PING	SOIL YIELD PCT.	WEEDS 300#/ UNIT	SOIL MOIST. 4=LOW
1	-6	2.06	0.238	2.27	18.0	0.0	3.2	2.0	4	3.0	98	0.0	2
2	-10	2.89	0.312	2.20	4.2	0.0	4.0	1.6	4	3.0	98	0.0	3
3	-7	2.94	0.264	2.72	3.8	0.0	3.6	2.0	4	3.0	98	0.0	2
4	-7	2.66	0.300	2.64	5.7	0.0	3.4	2.0	4	3.0	98	0.0	3
5	-10	2.84	0.303	2.46	17.1	0.0	3.4	2.0	4	3.0	98	0.0	2
6	-7	2.88	0.281	2.10	3.3	0.0	2.8	2.0	4	3.0	98	0.0	2
7	-3	1.86	0.228	2.16	12.2	0.0	3.4	1.8	4	3.0	98	0.0	3
8	-7	2.53	0.274	2.26	10.1	0.0	4.0	2.0	4	3.0	98	0.0	2
9	-10	2.71	0.286	2.46	5.3	0.0	3.8	1.8	4	3.0	98	0.0	3
10	8	2.89	0.280	2.18	21.5	0.0	3.2	2.2	4	3.0	98	0.0	3
11	-9	2.60	0.269	2.42	5.2	0.0	3.2	1.4	4	3.0	98	0.0	3
12	-7	2.59	0.272	2.22	9.3	0.0	3.4	2.2	4	3.0	98	0.0	3
13	-7	2.82	0.298	1.79	20.7	0.0	3.6	2.0	4	3.0	98	0.0	3
14	-9	2.92	0.297	2.44	16.9	0.0	3.8	2.2	4	3.0	98	0.0	2
15	-3	1.67	0.202	2.09	28.4	0.0	2.8	1.6	4	3.0	98	0.0	3
16	-5	2.25	0.240	2.68	8.2	0.0	3.0	1.8	4	3.0	98	0.0	3
17	-7	2.70	0.305	2.32	4.3	0.0	3.4	1.8	4	3.0	98	0.0	3
18	-8	2.80	0.302	1.95	8.2	0.0	4.0	1.8	4	3.0	98	0.0	4
19	-9	2.80	0.298	2.30	12.8	0.0	3.4	2.0	4	3.0	98	0.0	3
20	-7	2.90	0.284	2.02	6.2	0.0	3.8	2.0	4	3.0	98	0.0	4
21	-9	2.99	0.289	2.24	11.5	0.0	3.2	2.2	4	3.0	98	0.0	3
22	-8	2.63	0.270	2.25	7.8	0.0	4.0	1.8	4	3.0	98	0.0	2
23	-8	2.75	0.276	1.88	18.8	0.0	3.2	1.8	4	3.0	98	0.0	3
24	-8	2.79	0.268	2.32	7.9	0.0	3.0	1.4	4	3.0	98	0.0	3
25	-8	2.97	0.305	2.32	14.7	0.0	3.4	2.1	4	3.0	98	0.0	2

APPENDIX C. INFORMATION CONCERNING ROOTWORM-FERTILITY STUDY

Table 46. Correlation matrix for variables of rootworm-fertility experiment

		1	2	3	4	5	6	7	8	9	10	11	12
1.	Yield	1.00											
2.	Root size	0.26	1.00										
3.	Root damage	-.09	-.77	1.00									
4.	Insecticide	0.08	0.57	-.74	1.00								
5.	Fertilizer N_2	0.22	0.04	-.01	0.00	1.00							
6.	Fertilizer N^2	0.05	0.06	-.01	0.00	0.00	1.00						
7.	Fertilizer P_2	0.03	0.04	-.05	0.00	0.00	0.00	1.00					
8.	Fertilizer P^2	-.01	-.04	0.06	0.00	0.00	0.23	0.00	1.00				
9.	Fertilizer K_2	-.06	0.02	0.05	0.00	0.00	0.00	0.00	0.00	1.00			
10.	Fertilizer K^2	0.00	0.02	0.06	0.00	0.00	0.23	0.00	0.23	0.00	1.00		
11.	Fertilizer NP	0.04	-.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	
12.	Fertilizer NK	-.06	-.04	-.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
13.	Fertilizer PK	0.01	-.06	-.00	0.00	0.07	0.00	-.07	0.00	0.00	0.00	0.00	0.00
14.	Soil N	-.13	-.13	0.14	0.00	-.05	-.11	0.08	-.02	0.02	-.07	-.02	0.07
15.	Soil P	-.04	-.02	0.09	0.00	0.02	0.01	0.02	0.01	-.02	0.01	-.01	0.01
16.	Soil K	-.22	-.00	0.02	0.00	-.03	0.00	0.03	-.03	-.02	-.03	-.03	-.04
17.	Soil pH	-.17	-.02	-.01	0.00	0.06	-.02	-.02	-.01	-.05	-.02	0.09	-.05
18.	Total root lodg.	0.16	-.31	0.46	-.53	-.01	0.05	-.05	0.03	0.02	-.00	0.00	0.02
19.	Stand	-.23	-.23	0.07	-.01	-.00	-.08	-.05	-.03	0.01	0.04	-.01	-.02
20.	Planting date	-.45	0.12	-.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21.	Soil H_2O, D_3	0.15	0.07	-.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22.	Leaf N	0.32	0.12	-.04	0.03	0.64	-.21	-.02	-.05	0.03	-.07	0.02	-.03
23.	Leaf P	0.22	0.09	0.02	-.01	0.30	-.20	0.27	-.00	0.02	-.10	0.03	-.09
24.	Leaf K	-.37	0.06	-.06	0.08	0.05	-.03	0.09	-.03	0.25	-.01	0.03	0.00

Table 46. (Continued)

	13	14	15	16	17	18	19	20	21	22	23	24
1. Yield												
2. Root size												
3. Root damage												
4. Insecticide												
5. Fertilizer N												
6. Fertilizer N^2												
7. Fertilizer P												
8. Fertilizer P^2												
9. Fertilizer K												
10. Fertilizer K^2												
11. Fertilizer NP												
12. Fertilizer NK												
13. Fertilizer PK	1.00											
14. Soil N	0.10	1.00										
15. Soil P	0.07	0.65	1.00									
16. Soil K	-.04	0.64	0.81	1.00								
17. Soil pH	-.02	-.14	-.28	-.38	1.00							
18. Total root lodg.	0.01	-.25	-.32	-.42	0.18	1.00						
19. Stand	0.07	-.10	-.26	-.20	0.36	-.01	1.00					
20. Planting date	0.00	-.13	-.18	0.04	0.27	-.19	0.04	1.00				
21. Soil H_2O	0.00	-.14	-.12	-.17	0.38	0.18	0.23	-.05	1.00			
22. Leaf N	-.01	-.07	-.09	-.13	0.06	0.05	-.10	-.03	-.07	1.00		
23. Leaf P	0.02	0.10	0.05	-.06	0.29	0.25	-.14	-.11	0.19	0.56	1.00	
24. Leaf K	0.03	0.31	0.18	0.32	0.13	-.27	0.20	0.31	-.26	0.10	0.18	1.00

Table 47. Analyses of variance of grain yields from split plot design of rootworm-fertility experiments at each of six sites

Source of variation	df	Mean square[a]	F-ratio	Mean square[a]	F-ratio
		Site 20		Site 21	
WholePlot	24	231.24		174.03	
N	1	+420.30	1.55+	+214.97	1.55+
N^2	1	- .01		+1145.02	8.23***
P	1	- 11.80		- 11.58	
P^2	1	+483.21	1.79+	- 2.62	
K	1	+ 38.01		-132.75	
K^2	1	-115.38		+ 1.45	
NP	1	+171.43		- 5.24	
NK	1	- 58.49		-571.87	4.11*
PK	1	-208.66		+ 2.70	
Error(a)	15	269.50		139.23	
SubPlots	25	58.72		97.43	
I	1	- 31.86		+897.25	12.4***
NI	1	- 16.57		- 39.75	
PI	1	+ 1.21		+ 3.60	
KI	1	-176.92	2.99+++	- 2.28	
Error(b)	21	1123.99		72.11	
		Site 22		Site 38	
WholePlot	24	294.59		249.56	
N	1	+605.29		+1674.03	12.2***
N^2	1	+300.70		-201.21	1.47+
P	1	- 48.12		+607.81	4.45*
P^2	1	+325.08		-159.56	1.17
K	1	-777.75	2.47++	-292.11	2.14++
K^2	1	+ .01		-733.78	5.37*
NP	1	-109.38		+ 49.12	
NK	1	-180.86		+ 8.29	
PK	1	+ 6.64		-209.88	1.54+
Error(a)	15	314.42		136.75	
SubPlots	25	61.10		139.84	
I	1	+ 62.79		+1308.99	11.9***

[a]Signs preceding Mean squares indicate direction of effect.

Table 47. (Continued)

Source of variation	df	Mean square	F-ratio	Mean square	F-ratio
NI	1	7.36		- 4.05	
PI	1	+ 17.88		-109.71	
KI	1	- 1.40		-386.38	3.50+++
Error(b)	21	69.26		110.46	
		Site 39		Site 40	
WholePlot	24	265.78		238.03	
N	1	+986.78	6.31*	+1007.67	4.14*
N^2	1	- 83.71		+ 11.57	
P	1	+1935.62	12.4***	+346.46	1.42+
P^2	1	-205.56	1.60+	-149.11	
K	1	-418.37	2.67++	-316.35	1.30+
K^2	1	- 98.72		+ 21.63	
NP	1	- 24.00		+ 9.85	
NK	1	-101.30		- 69.10	
PK	1	+178.57	1.14+	-125.65	
Error(a)	15	156.60		243.69	
SubPlots	25	377.75		214.63	
I	1	+247.75		+809.79	4.10*
NI	1	-232.80		+ 54.34	
PI	1	+338.82		+139.50	
KI	1	- 59.35		-166.60	
Error(b)	21	407.90		197.31	

Table 48. Analyses of variance of root size (recovery) ratings of rootworm-fertility experiments at each of six sites

Source of variation	df	Mean square[a]	F-ratio	Mean square[a]	F-ratio
		Site 20		Site 21	
WholePlots	24	.1951		.5017	
N	1	-.0516		-.7015	1.27+
N^2	1	+1.2911	15.1***	+.3832	
P	1	+.0685		-.5107	
P^2	1	-.1544	1.80+	-1.8908	3.42+++
K	1	-.0032		+.1859	
K^2	1	-.0229		-.0000	
NP	1	-.0819		-.4159	
NK	1	-.0973	1.13	-.0001	
PK	1	-1.8792	21.9***	-.1253	
Error(a)	15			.5533	
Subplots	25	1.1864		.1864	
I	1	+25.0632	115.***	+.0648	
NI	1	-.0848		-.7009	4.85*
PI	1	+.3711	1.70+	-.0007	
KI	1	-.0128		-.8596	5.95*
Error(b)	21	.2189		.1445	
		Site 22		Site 38	
WholePlots	24	.3918		.2585	
N	1	+.1624		+.8138	4.66*
N^2	1	+1.0762	2.59++	-.1897	1.09
P	1	+.1145		+.1594	
P^2	1	+.6342	1.53	-.1895	1.08
K	1	-.1572		-.1707	
K^2	1	-.1099		+.0164	
NP	1	-.6720	1.62+	+1.3104	7.45*
NK	1	-.1386		-.7093	4.06+++
PK	1	+.1463		+.0004	
Error(a)	15	.4148		.1745	
Subplots	25	1.0090		.5450	
I	1	+16.0178		+7.2962	

[a]Signs preceding Mean squares indicate direction of effect.

Table 48. (Continued)

Source of variation	df	Mean square	F-ratio	Mean square	F-ratio
NI	1	+.0004		-.4450	1.71+
PI	1	+.0128		-.4110	1.58+
KI	1	+.5953	1.44+	-.0196	
Error(b)	21	.4095		.2597	
		Site 39		Site 40	
WholePlots	24	.2708		.1301	
N_2	1	+.2296		+.0732	
N^2	1	-.0231		+.0111	
P_2	1	+.1896		+.4278	3.87+++
P^2	1	-.4035	1.26+	+.1203	
K_2	1	+.4542	1.41+	+.2417	2.19++
K^2	1	+.5383	1.68+	+.0111	
NP	1	-.0054		+.0277	
NK	1	+.0307		+.0022	
PK	1	+.1328		-.5088	4.61*
Error(a)	15	.3210		.1106	
SubPlots	25	.7314		.2204	
I	1	+14.2578		+2.3767	17.5***
NI	1	+.0957		+.0597	
PI	1	+.0348		-.0659	
KI	1	-.1219		+.1950	1.44+
Error(b)	21	.1798		.1360	

Table 49. Analyses of variance of root damage ratings of rootworm-fertility experiments at each of six sites

Source of variation	df	Mean square[a]	F-ratio	Mean square[a]	F-ratio
		Site 20		Site 21	
WholePlots	24	.1869		.1025	
N	1	+.1084		-.0325	
N^2	1	-.0954		-.2900	3.31+++
P	1	+.0033		+.0026	
P^2	1	-.0521		+.1829	2.09++
K	1	+.3523	3.25+++	+.2272	2.59++
K^2	1	+.3329	3.07+++		
NP	1	+.5838	5.38*	+.0052	
NK	1	-.0821		+.0249	
PK	1	+.0336		+.0772	
Error(a)	15	.1085		.0877	
SubPlots	25	2.3348		.1850	
I	1	-53.6650	240.***	-2.6450	29.5***
NI	1	-.3262	1.46+	+.0486	
PI	1	+.0441		-.0314	
KI	1	-.1286		-.0161	
Error(b)	21	.2240		.0897	
		Site 22		Site 38	
WholePlots	24	.2235		.2071	
N	1	-.3039	1.16	-.2517	1.86+
N^2	1	-.2480		-.1038	
P	1	+.2292		-.3116	2.31++
P^2	1	-.0002		+.9334	6.89*
K	1	+.0323		+.0182	
K^2	1	+.2194		+.1621	1.20
NP	1	+.6792	2.59++	-.6725	4.97*
NK	1	-.3729	1.52+	+.1001	
PK	1	+.3818	1.46+	-.4104	3.03+++
Error(a)	15	.2624		.1354	
SubPlots	25	.8624		.7596	
I	1	-16.5888	92.9***	-14.3648	89.2***

[a]Signs preceding Mean squares indicate direction of effect.

Table 49. (Continued)

Source of variation	df	Mean square	F-ratio	Mean square	F-ratio
NI	1	-.0374		+.6128	3.81+++
PI	1	-.0027		+.5677	3.53+++
KI	1	-.2042	6.79*	-.0628	
Error(b)	21	.1775		.1610	
		Site 39		Site 40	
WholePlots	24	.1592		.1296	
N_2	1	+.0447		+.0000	
N^2	1	+.4740	3.66+++	-.1379	1.14
P_2	1	-.3242	2.51++	-.6210	5.11*
P^2	1	+.5913	4.56*	+.0010	
K_2	1	-.0930		+.2275	1.87+
K^2	1	-.0389		+.0125	
NP	1	+.0920		-.1685	1.39+
NK	1	-.0096		-.0123	
PK	1	-.0980		+.1290	1.06
Error(a)	15	.1296		.1216	
SubPlots	25	1.5058		.4714	
I	1	-34.7778		-9.3794	84.6***
NI	1	-.1847		-.0114	
PI	1	+.0308		+.0134	
KI	1	+.0493		+.0134	
Error(b)	21	.1263		.1109	

APPENDIX D. TABLE 50. DATA FROM PLOTS WITH NO INSECTICIDE IN ROOTWORM-FERTILITY STUDY

The following explanations of symbols apply to the data which are recorded on the following 6 pages.

TRT NO.	Applied N, P, K, treatments as given in Table 6
ROOT SIZE	Root rating for size (recovery) as defined in Table 4
ROOT DAMAGE	Root rating for damage by corn rootworm as defined in Table 4
TOTAL ROOT LODG%	Percentage of plants which formed an angle with the ground of 60° or less
TOTAL STALK LODG%	Percentage of plants which were broken off either above or below the ear
SILK. DATE	Date at which 75% of plants were showing silks were coded around July 31 equal to 0

SITE NO. 20

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	ROOT SIZE	ROOT DAM-AGE	TOTAL ROOT LODG%	TOTAL STALK LODG%	LEAF %N	LEAF %P	LEAF %K	SILK. DATE AUG1=1
1	56.2	23400	33.0	1.4	3.8	35.2	0.5	2.50	0.234	2.61	1
2	62.7	24100	34.3	1.4	4.8	22.3	1.0	2.85	0.293	2.64	-1
3	66.3	23000	29.2	2.2	3.8	26.7	1.0	2.94	0.271	2.70	2
4	52.9	24100	42.9	2.0	4.0	23.5	0.0	2.42	0.257	2.25	3
5	64.2	21700	30.2	1.6	4.4	6.2	2.1	2.80	0.291	2.66	2
6	60.5	24400	26.8	2.4	3.4	3.9	0.0	2.84	0.266	2.54	-1
7	48.8	22000	29.7	2.8	2.8	0.0	0.0	2.60	0.260	2.82	-1
8	82.4	23000	23.9	2.6	4.2	4.9	1.0	2.60	0.257	2.58	1
9	50.8	22700	37.9	2.2	3.8	2.0	0.0	2.58	0.266	2.70	1
10	61.8	23700	31.9	1.6	4.4	44.1	4.0	2.82	0.284	2.40	-1
11	36.5	23400	41.2	2.4	3.4	1.0	0.0	2.60	0.269	2.64	1
12	43.2	22000	23.4	2.0	3.8	4.0	0.0	2.66	0.273	2.68	1
13	40.4	22000	42.2	2.8	3.4	3.0	1.0	2.82	0.276	2.70	1
14	83.2	24100	21.4	3.0	3.8	10.1	1.1	2.81	0.268	2.76	-1
15	68.7	22700	30.3	2.2	3.6	19.6	1.0	2.48	0.238	2.76	3
16	50.8	23400	36.0	2.0	3.4	1.0	0.0	2.59	0.249	2.72	1
17	52.6	23000	44.8	1.8	3.0	20.5	0.0	2.74	0.276	2.84	3
18	56.5	21300	33.9	1.4	4.4	0.0	0.0	2.79	0.291	2.56	1
19	49.8	24100	41.4	2.2	3.6	17.8	2.0	2.63	0.257	2.41	2
20	73.6	23000	23.9	1.6	4.6	23.8	0.0	2.79	0.270	2.54	1
21	84.6	25500	23.0	1.8	5.0	24.7	0.0	2.69	0.286	2.76	-1
22	39.1	23000	48.0	2.0	3.8	1.0	0.0	2.71	0.263	2.84	2
23	28.2	25500	54.1	1.8	3.4	0.0	0.0	2.66	0.263	2.56	2
24	55.5	22700	37.9	2.4	4.4	19.3	1.0	2.80	0.256	2.24	1
25	59.0	24250	31.7	1.6	4.5	34.5	3.5	2.74	0.276	2.53	2

SITE NO. 21

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	ROOT SIZE	ROOT DAM-AGE	TOTAL ROOT LODG%	TOTAL STALK LODG%	LEAF %N	LEAF %P	LEAF %K	SILK. DATE AUG1=1
1	68.6	18400	10.6	3.1	2.2	4.8	0.0	2.56	0.250	2.33	-4
2	72.4	17000	15.4	2.4	2.2	0.0	0.0	2.80	0.271	2.12	-2
3	71.8	14700	8.9	4.0	2.0	0.0	0.0	2.77	0.231	2.66	-3
4	70.3	17000	7.7	3.0	2.8	1.2	0.0	2.64	0.264	2.52	-2
5	56.0	12700	12.8	2.6	3.0	4.2	0.0	2.93	0.281	2.80	-3
6	83.2	16000	10.2	3.6	2.0	0.0	0.0	2.72	0.256	2.50	-3
7	60.8	13700	9.5	2.8	2.2	20.6	1.6	2.53	0.246	2.26	-2
8	64.2	17300	7.5	3.4	2.6	4.0	1.3	2.63	0.243	2.62	-3
9	66.3	17600	9.3	3.8	2.8	13.7	0.0	2.64	0.265	2.54	-4
10	75.3	18900	10.3	4.2	1.8	0.0	0.0	2.68	0.245	2.46	-4
11	92.1	18600	5.3	3.2	1.8	5.1	1.3	2.39	0.240	2.20	-4
12	56.6	8800	11.1	4.2	2.0	0.0	0.0	2.70	0.265	2.46	-3
13	80.6	18300	10.7	3.8	1.4	1.4	1.4	2.79	0.256	2.42	-4
14	69.0	17300	7.5	3.2	2.0	1.5	0.0	2.72	0.274	2.60	-4
15	64.0	16700	11.8	3.4	2.2	1.4	0.0	2.61	0.248	2.27	-3
16	73.2	18600	10.5	4.2	2.0	0.0	0.0	2.49	0.240	2.54	-4
17	52.8	14000	7.0	4.8	2.0	0.0	1.9	2.65	0.265	2.42	-3
18	63.5	17600	1.1	2.6	2.4	2.6	1.3	2.87	0.277	2.52	-3
19	55.3	19600	15.0	2.4	3.0	8.6	1.1	2.66	0.263	2.50	-2
20	52.2	14000	11.6	2.8	2.6	6.6	1.6	2.88	0.262	2.48	-3
21	59.8	15700	12.5	3.6	2.4	0.0	1.6	2.72	0.264	2.68	-4
22	49.4	15400	12.8	4.2	2.0	0.0	0.0	2.62	0.270	2.60	-1
23	52.2	18900	13.8	2.6	2.6	1.2	3.7	2.54	0.241	2.01	-3
24	55.6	16700	13.7	3.2	2.4	12.8	2.6	2.60	0.245	2.34	-4
25	52.8	18100	19.0	2.5	2.6	2.5	1.8	2.78	0.261	2.48	-2

SITE NO. 22

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	ROOT SIZE	ROOT DAM-AGE	TOTAL ROOT LODG%	TOTAL STALK LODG%	LEAF %N	LEAF %P	LEAF %K	SILK. DATE AUG1=1
1	98.4	16500	4.9	3.3	3.3	4.2	3.0	2.60	0.256	2.32	-4
2	90.2	16300	6.0	3.0	3.0	1.3	5.1	2.82	0.282	2.34	-3
3	86.9	16300	10.0	2.8	3.0	0.0	4.4	2.90	0.276	2.54	-4
4	70.4	14000	14.0	3.2	3.4	0.0	4.4	2.65	0.273	2.50	-3
5	78.8	16700	5.9	2.0	4.2	11.6	2.6	2.49	0.265	2.32	-5
6	105.2	17600	9.3	2.4	3.8	5.2	3.9	2.61	0.266	2.35	-5
7	88.4	15400	10.6	2.2	3.0	1.3	5.4	2.69	0.269	2.37	-5
8	71.0	16000	10.2	1.2	4.6	7.5	3.0	2.46	0.260	2.44	-2
9	99.6	15400	6.4	3.0	3.2	9.4	9.4	2.70	0.292	2.40	-4
10	88.3	15700	8.3	3.0	2.4	6.1	3.7	2.70	0.263	2.34	-5
11	99.7	14700	4.4	3.4	3.0	0.0	3.0	2.62	0.267	2.56	-4
12	99.3	15700	4.2	2.8	3.0	0.0	10.1	2.63	0.271	2.24	-4
13	74.2	14700	4.4	3.2	3.2	9.0	12.0	2.79	0.286	2.38	-5
14	93.3	15400	8.5	2.2	3.6	4.2	2.8	2.85	0.284	2.56	-5
15	78.0	17300	9.4	2.2	3.2	9.4	8.5	2.59	0.261	2.31	-4
16	72.9	16000	14.3	2.0	3.2	2.7	6.8	2.41	0.250	2.32	-4
17	70.2	15400	4.3	2.2	3.8	3.6	11.3	2.72	0.294	2.62	-5
18	64.2	13700	14.3	1.4	4.0	16.2	8.8	2.85	0.302	2.50	-5
19	75.5	14400	4.5	2.4	3.0	4.3	4.3	2.65	0.278	2.68	-4
20	77.9	15700	8.3	2.0	3.6	2.7	6.8	2.72	0.277	2.42	-4
21	66.2	15400	14.9	2.2	3.6	5.8	8.6	2.71	0.267	2.56	-5
22	53.1	14400	11.4	1.6	4.2	34.8	5.7	2.69	0.291	2.60	-4
23	69.1	16300	12.0	2.0	3.4	0.0	11.1	2.65	0.262	2.54	-3
24	86.3	13400	9.8	2.8	3.6	2.9	2.9	2.90	0.279	2.22	-6
25	91.1	15200	7.6	2.5	3.4	6.5	8.7	2.70	0.272	2.36	-4

SITE NO. 38

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	ROOT SIZE	ROOT DAM-AGE	TOTAL ROOT LODG%	TOTAL STALK LODG%	LEAF %N	LEAF %P	LEAF %K	SILK. DATE AUG1=1
1	60.0	16500	14.8	2.3	3.4	87.6	4.8	2.43	0.295	2.42	-2
2	94.0	14400	4.5	4.2	2.4	68.0	2.7	3.12	0.319	2.40	-6
3	70.8	16000	8.0	1.8	4.4	91.4	3.3	2.99	0.296	2.32	-2
4	76.3	15400	2.1	2.6	3.6	93.6	1.3	2.69	0.306	2.34	-2
5	87.3	13700	4.8	3.2	2.6	77.5	2.8	3.14	0.306	2.46	-4
6	68.7	16700	13.2	2.4	3.4	96.2	10.1	2.72	0.291	2.34	-3
7	28.9	14400	56.8	1.6	4.2	91.6	0.2	2.87	0.218	5.09	**
8	80.4	18300	7.1	2.8	3.4	89.9	3.4	2.56	0.294	2.34	-2
9	107.8	16700	2.0	3.4	2.4	42.5	1.2	3.13	0.307	2.40	-5
10	78.5	15000	13.0	3.6	2.4	53.8	3.7	2.84	0.295	2.06	-4
11	99.7	16000	6.1	3.0	2.8	59.1	4.5	3.04	0.308	2.52	-6
12	65.4	17000	15.4	3.0	3.8	92.7	1.2	2.61	0.283	2.50	-3
13	102.3	17000	5.8	3.2	2.8	94.8	0.0	2.99	0.289	2.26	-4
14	115.6	16700	5.9	3.8	2.2	48.6	2.9	3.24	0.290	2.40	-6
15	84.9	15700	4.2	2.8	3.0	93.0	1.4	2.55	0.296	2.42	-3
16	97.4	17000	1.9	3.0	2.6	85.8	4.3	2.50	0.289	2.58	-5
17	101.5	15400	4.3	3.0	2.8	83.5	8.9	2.85	0.294	2.30	-5
18	80.7	15700	8.3	2.6	3.4	85.9	2.4	3.18	0.292	2.40	-4
19	86.4	18000	5.5	2.0	4.0	103.3	3.3	2.91	0.275	2.40	-3
20	98.3	17000	5.8	3.2	3.2	85.2	2.4	2.92	0.291	2.10	-4
21	98.2	18000	14.5	3.4	2.2	61.1	2.6	2.85	0.301	2.54	-7
22	95.0	18300	14.3	2.6	3.6	73.4	1.3	2.88	0.289	2.48	-4
23	93.0	17600	9.3	3.4	3.0	78.0	4.4	3.08	0.302	2.48	-7
24	89.8	16700	2.0	3.0	3.0	91.0	7.7	2.30	0.277	2.32	-5
25	85.0	16000	8.1	2.9	3.3	62.3	0.6	2.75	0.296	2.16	-4

SITE NO. 39

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	ROOT SIZE	ROOT DAM-AGE	TOTAL ROOT LODG%	TOTAL STALK LODG%	LEAF %N	LEAF %P	LEAF %K	SILK. DATE AUG1=1
1	85.0	16600	15.0	2.5	3.8	42.9	9.0	2.54	0.224	1.99	-4
2	113.7	21300	11.3	2.0	4.4	33.3	22.6	2.97	0.268	2.36	-7
3	76.0	16900	24.5	2.0	4.4	63.6	17.6	2.80	0.227	1.92	-5
4	68.6	15800	21.7	2.8	3.4	31.9	21.7	2.35	0.254	2.34	-4
5	105.1	19300	7.1	2.2	4.0	66.7	23.8	2.75	0.252	1.96	-5
6	89.6	17200	16.0	2.2	4.0	44.0	16.0	2.95	0.258	2.04	-4
7	82.7	20000	13.8	2.2	3.2	16.1	13.8	2.45	0.260	2.00	-5
8	86.3	17200	16.0	2.8	3.6	38.7	12.0	2.80	0.234	2.36	-4
9	93.6	19600	14.0	3.6	2.8	47.7	24.4	2.90	0.278	2.38	-5
10	85.6	19600	17.5	2.4	3.6	53.5	12.8	2.91	0.279	2.44	-4
11	98.9	17500	11.8	2.4	3.4	19.7	11.8	2.53	0.249	2.30	-5
12	67.3	18900	20.0	1.8	3.0	51.2	14.6	2.31	0.220	2.16	-4
13	97.9	20300	15.3	2.4	3.0	39.8	14.8	2.93	0.268	2.46	-6
14	95.5	16900	14.3	2.6	4.0	54.1	10.8	2.89	0.246	1.72	-4
15	105.1	17900	7.7	2.0	3.8	25.6	16.7	2.66	0.238	2.02	-5
16	38.1	17200	40.0	1.6	4.0	61.4	9.4	2.55	0.225	2.01	-1
17	78.5	16200	25.5	1.6	4.4	68.6	7.1	2.54	0.264	1.89	-4
18	107.2	18200	5.7	2.6	3.0	16.3	15.0	2.88	0.282	2.45	-6
19	79.7	17500	15.7	2.0	3.8	35.5	11.8	2.80	0.229	2.34	-4
20	94.1	18200	17.0	2.2	4.0	23.8	15.0	2.62	0.249	2.26	-5
21	112.5	17200	12.0	3.4	3.0	21.3	29.3	2.70	0.249	2.28	-5
22	100.3	18200	13.2	3.0	2.8	10.0	11.3	2.87	0.262	2.44	-4
23	97.7	17200	10.0	3.0	3.0	24.0	12.0	2.85	0.250	2.26	-4
24	99.7	19300	17.9	2.0	4.0	40.5	17.9	2.78	0.259	2.12	-6
25	93.0	17000	10.8	3.1	3.1	58.6	15.6	2.77	0.262	2.20	-4

SITE NO. 40

TRT NO.	YIELD BU/A	STAND PLANT /A	BAR-REN %	ROOT SIZE	ROOT DAM-AGE	TOTAL ROOT LODG%	TOTAL STALK LODG%	LEAF %N	LEAF %P	LEAF %K	SILK. DATE AUG1=1	SOIL MOIST. 4=LOW
1	76.6	22700	33.2	2.7	2.8	62.1	0.0	2.28	0.234	2.30	-4	2
2	127.8	22700	7.6	3.0	2.2	42.2	0.0	2.92	0.302	2.36	-9	3
3	110.8	20300	20.3	3.2	3.0	56.8	0.0	2.98	0.272	2.32	-8	1
4	81.7	22700	21.2	2.8	3.4	64.6	0.0	2.31	0.276	2.50	-7	3
5	130.8	21300	16.1	3.2	2.2	51.1	0.0	2.75	0.286	2.48	-7	1
6	128.0	18900	9.1	3.4	2.6	23.3	0.0	2.95	0.275	2.05	-7	1
7	75.9	22000	39.1	3.6	2.4	73.4	0.0	2.44	0.275	2.38	-5	3
8	110.5	20300	15.3	3.2	2.6	64.1	0.0	2.50	0.253	2.28	-7	1
9	65.1	19600	26.3	3.4	2.8	47.6	0.0	2.90	0.284	2.58	-7	3
10	83.7	22700	20.7	2.6	2.4	62.6	0.0	2.95	0.277	2.32	-8	3
11	83.8	21000	11.5	3.2	2.6	31.2	0.0	2.68	0.299	2.48	-8	3
12	59.0	23000	29.9	2.4	2.8	64.8	0.0	2.80	0.282	2.14	-6	3
13	89.0	21700	19.0	2.4	2.0	46.5	0.0	2.99	0.300	2.18	-6	3
14	118.0	16900	14.3	3.2	3.6	74.0	0.0	2.81	0.290	2.54	**	1
15	89.8	24000	32.9	3.6	2.4	65.0	0.0	2.24	0.269	2.28	-5	3
16	73.7	23400	30.9	3.0	2.6	34.0	0.0	2.45	0.295	2.62	-6	3
17	55.7	21000	13.1	3.2	2.6	23.5	0.0	2.75	0.290	2.22	-7	3
18	92.9	18900	16.4	3.2	2.4	38.5	0.0	2.73	0.277	2.03	-6	3
19	82.4	22400	24.6	2.6	3.4	56.4	0.0	2.82	0.298	2.30	-7	3
20	92.6	22400	9.2	2.4	3.2	74.7	0.0	2.89	0.283	2.08	-8	3
21	53.2	22700	39.4	2.8	3.0	49.0	0.0	2.84	0.266	2.32	-6	3
22	111.2	23400	26.5	3.4	2.8	54.1	0.0	2.82	0.274	2.54	-6	2
23	108.8	23000	20.9	2.8	3.0	35.2	0.0	2.85	0.277	2.04	-6	3
24	55.7	23400	36.8	3.0	3.4	28.4	0.0	2.95	0.285	2.40	-6	3
25	99.6	20300	10.4	2.9	2.8	35.8	0.0	2.92	0.296	2.43	-8	2